

INSTRUCTION MANUAL



RACAL-DANA

RACAL

The Electronics Group

PUBLICATION NO. 980657

1993

UNIVERSAL TIMER/COUNTERS

RACAL-DANA

RACAL-DANA INSTRUMENTS INC.

4 Goodyear Street, P.O. Box C-19541, Irvine, CA 92713
Telephone: 714/859-8999, TWX: 910-595-1136, TLX: 67-8341

RACAL-DANA INSTRUMENTS LTD.

Hardley Industrial Estate, Hythe, Southampton, Hampshire, SO4 6ZH, England
Telephone: (0703) 843265, FAX: (0703) 848919, TLX: 47600

RACAL-DANA INSTRUMENTS S.A.

18 Avenue Dutartre, 78150 Le Chesnay, France
Telephone: (1) 3-955-8888, TLX: 697 215

RACAL-DANA INSTRUMENTS GmbH.

Hermannstrasse 29, D-6078 Neu Isenburg, Federal Republic of Germany
Telephone: 06102-2861/2, TLX: 412896

RACAL-DANA INSTRUMENTS ITALIA srl.

Via Mecenate 84/A, 20138 Milano MI, Italy
Telephone: (02) 5062767, (02) 5052686, (02) 503444; TLX: 315697

RACAL

PUBLICATION DATE: OCTOBER 1989

Copyright © 1989 by Racal-Dana Instruments Inc. Printed in the United States of America. All rights reserved.
This book or parts thereof may not be reproduced in any form without written permission from the publishers.

WARRANTY

Within one year of purchase, Racal-Dana will repair or replace your instrument, at our option, if in any way it is defective in material or workmanship. The instrument must be returned to the country of purchase, unless prior arrangement has been made, and Racal-Dana Instruments will pay all parts and labor charges. Just call Racal-Dana Customer Service at (714) 859-8999 in U.S.A., (0703) 843265 in England, (1) 3-955-8888 in France, 06102-2861/2 in Germany or (02) 5062767, 5052686, or 503444 in Italy for assistance. We will advise you of the proper shipping address for your prepaid shipment. Your instrument will be returned to you freight prepaid.

PROPRIETARY NOTICE

This document and the technical data herein disclosed, are proprietary to Racal-Dana Instruments, Inc., and shall not, without express written permission of Racal-Dana Instruments, Inc., be used, in whole or in part to solicit quotations from a competitive source or used for manufacture by anyone other than Racal-Dana Instruments, Inc. The information herein has been developed at private expense, and may only be used for operation and maintenance reference purposes or for purposes of engineering evaluation and incorporation into technical specifications and other documents which specify procurement of products from Racal-Dana Instruments, Inc.

FOR YOUR SAFETY

Before undertaking any maintenance procedure, whether it be a specific troubleshooting or maintenance procedure described herein or an exploratory procedure aimed at determining whether there has been a malfunction, read the applicable section of this manual and note carefully the **WARNING** and **CAUTION** notices contained therein.

The equipment described in this manual contains voltage hazardous to human life and safety and which is capable of inflicting personal injury. The cautionary and warning notes are included in this manual to alert operator and maintenance personnel to the electrical hazards and thus prevent personal injury and damage to equipment.

If this instrument is to be powered from the AC line (mains) through an autotransformer (such as a Variac or equivalent) ensure that the common connector is connected to the neutral (earthed pole) of the power supply.

Before operating the unit ensure that the protective conductor (green wire) is connected to the ground (earth) protective conductor of the power outlet. Do not defeat the protective feature of the third protective conductor in the power cord by using a two conductor extension cord or a three-prong/two-prong adaptor.

Maintenance and calibration procedures contained in this manual sometimes call for operation of the unit with power applied and protective covers removed. Read the procedures carefully and heed Warnings to avoid "live" circuit points to ensure your personal safety.

Before operating this instrument:

1. Ensure that the instrument is configured to operate on the voltage available at the power source. See Installation Section.
2. Ensure that the proper fuse is in place in the instrument for the power source on which the instrument is to be operated.
3. Ensure that all other devices connected to or in proximity to this instrument are properly grounded or connected to the protective third-wire earth ground.

If at any time the instrument:

- Fails to operate satisfactorily
- Shows visible damage
- Has been stored under unfavorable conditions
- Has sustained stress

It should not be used until its performance has been checked by qualified personnel.

FOR YOUR SAFETY



Digitized by the Internet Archive
in 2025

https://archive.org/details/manualsplus_07281

TABLE OF CONTENTS

<u>Section</u>	<u>Title</u>	<u>Page</u>
1	GENERAL INFORMATION	1-1
1.1	Introduction	1-1
1.2	Measurement Functions	1-1
1.2.1	Frequency A and B	1-1
1.2.2	Frequency C.....	1-1
1.2.3	Period A	1-1
1.2.4	Time Interval.....	1-1
1.2.5	Total A by B.....	1-1
1.2.6	Ratio A/B.....	1-2
1.2.7	Ratio C/B.....	1-2
1.2.8	Rise/Fall A.....	1-2
1.2.9	Pulse Width A	1-2
1.2.10	Phase A rel B.....	1-2
1.2.11	Check	1-2
1.3	Signal Input Channels	1-2
1.4	Low-Pass Filter	1-3
1.5	Math Computation	1-3
1.6	Special Functions	1-3
1.7	Error Indication	1-3
1.8	External Arming	1-3
1.9	Hold.....	1-3
1.10	Gate Time and Resolution	1-4
1.11	Available Option	1-4
1.11.1	1.3 GHz Input C (Option 41)	1-4
1.12	Safety	1-4
1.13	Product Support.....	1-4
1.14	Specifications	1-5
2	INSTALLATION.....	2-1
2.1	Introduction	2-1
2.2	Unpacking and Inspection.....	2-1
2.3	Reshipment Instructions.....	2-1
2.4	1993 Module Installation	2-1
2.5	Storage and Temperature.....	2-1
2.6	Functional Check	2-1
2.6.1	Introduction	2-1
3	LOCAL OPERATION	3-1
3.1	Introduction	3-1
3.2	General Operating Information.....	3-1
3.2.2	Power-On and Self Test	3-1
3.2.3	Home State	3-1
3.2.4	Main Display	3-2
3.3	Front-Panel/Keyboard Organization	3-2
3.4	Measurement and Operating Procedures	3-12
3.4.1	Frequency Measurement	3-12
3.4.2	Period Measurement	3-13

TABLE OF CONTENTS (Cont'd)

<u>Section</u>	<u>Title</u>	<u>Page</u>
3.4.3	Time Interval Measurement	3-13
3.4.4	Manual Totalize Measurement	3-14
3.4.5	Ratio A/B Measurement	3-15
3.4.6	Rise/Fall A Measurement	3-16
3.4.7	Pulse Width A Measurement	3-16
3.4.8	Phase A rel B Measurement	3-17
3.4.9	Gate-Time Setting	3-18
3.4.10	Resolution Setting	3-18
3.4.11	Manual Trigger Level Setting	3-18
3.4.12	Auto-Triggering Level Recall	3-19
3.4.13	50-Ohm Impedance Selection	3-19
3.4.14	Positive/Negative Slope Selection	3-19
3.4.15	AC/DC Coupling Selection	3-19
3.4.16	Peak Voltage Level Recall	3-20
3.4.17	X, Y and Z Constant Storage	3-20
3.4.18	Separate/Common Mode Selection	3-21
3.4.19	Attenuation Level Setting	3-21
3.4.20	Filter Selection	3-21
3.4.21	Auto-Trigger	3-21
3.4.22	Check Mode Entry	3-22
3.5	Miscellaneous Operating Information	3-22
3.5.1	Trigger Level Setting	3-22
3.5.1.1	Introduction	3-22
3.5.1.2	Manual Trigger Setting	3-22
3.5.1.3	Auto-Trigger Setting	3-23
3.5.1.4	Single-Shot Auto-Trigger	3-23
3.5.1.5	Automatic Attenuation Setting	3-23
3.5.2	Display Resolution	3-24
3.5.2.4	Display Resolution Setting	3-24
3.5.3	Gate Time	3-24
3.5.3.2	Gate Time Storage/Recall	3-25
3.5.4	Stop Arm Delay (Hold Off)	3-25
3.5.4.3	Stop Arm Delay Storage	3-26
3.5.4.4	Stop Arm Delay Recall	3-26
3.5.4.5	Stop Arm Delay Enabling/Disabling	3-26
3.5.5	Math Function (R0X) Y/Z	3-26
3.5.5.2	Math Constant Storage/Recall	3-27
3.5.5.3	Displayed Reading Storage	3-27
3.5.5.4	Math Function Enabling/Disabling	3-27
3.5.6	100 Average Function	3-27
3.5.6.2	100 Average Function Enabling/Disabling	3-27
3.5.7	Special Functions	3-27
3.5.7.3	Special Function Storage	3-27
3.5.7.4	Special Function Recall	3-28
3.5.7.5	Special Function Enabling/Disabling	3-28
3.5.8	Error Codes	3-30
3.5.8.2	Error Code Clearance	3-31

TABLE OF CONTENTS (Cont'd)

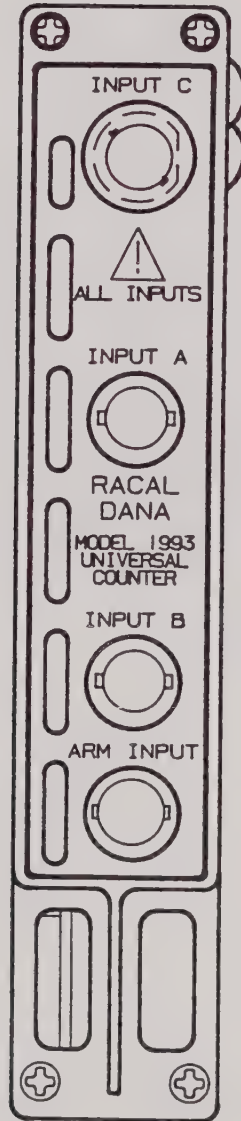
<u>Section</u>	<u>Title</u>	<u>Page</u>
4	SYSTEM OPERATION	4-1
4.1	GPIB Functional Check	4-1
4.1.1	Introduction	4-1
4.1.2	Data Output Check	4-1
4.2	Addressed Mode	4-2
4.3	Output Message Format (Talker)	4-2
4.3.1	Introduction	4-2
4.4	Status Byte	4-3
4.4.1	General	4-3
4.4.2	SRQ Enable Register (Mask)	4-3
4.4.3	Event Status Enable Register (Mask)	4-3
4.4.4	Status Byte and Event Status Registers	4-3
4.5	Input Commands	4-7
4.5.1	Introduction	4-7
4.5.2	Device-Dependent Commands	4-7
5	GENERAL THEORY OF OPERATION	5-1
5.	1 Introduction	5-1
5.2	Functional Blocks	5-1
5.3	Theory of Operation by Block	5-3
5.3.1	Channel A/B Block	5-3
5.3.2	Channel C (Option 40) Block	5-5
5.3.3	Measurement Block	5-6
5.3.4	Microprocessor Block	5-10
5.3.5	IRQ Block	5-12
5.3.6	DC Filter Block	5-14
5.3.7	Model 680 Interface	5-15
6	DRAWINGS	6-1
7	PARTS LIST	7-1

LIST OF ILLUSTRATIONS

<u>Figure</u>	<u>Title</u>	<u>Page</u>
1-1	Store and Recall Codes	1-7
2-1	1993 Module Installation	2-2
3-1	1993 Menu Flowchart	3-11
3-2	Use of Stop Arm Delay	3-26
3-3	Special Function Register Display	3-30
4-1	1993 Status Data Definition	4-4
5.1	Simplified 1993 Block Diagram	5-2
5.2	Channel A/B Block Diagram	5-3
5.3	Channel C Block Diagram	5-5
5.4	Measurement-Block Diagram	5-7
5.5	Basic Recipromatic Counting Technique	5-8
5.6	Microprocessor-Block Diagram	5-11
5.7	IRQ Block Diagram	5-13
5.8	Power Supply Block Diagram	5-14

LIST OF TABLES

<u>Table</u>	<u>Title</u>	<u>Page</u>
1-1	1993 Specifications	1-5
3-1	680 Front-Panel Organization	3-3
3-2	Resolution and Gate Time	3-24
3-3	Special Functions (SFs).....	3-29
3-4	Error Codes	3-30
4-1	Output Message Format	4-2
4-2	Status Byte Error Codes.....	4-5
4-3	Instrument Preset Code	4-7
4-4	Numerical Input Format.....	4-8
4-5	Measurement Function Codes	4-9
4-6	Numerical Input Ranges	4-10
4-7	Resolution Selection	4-11
4-8	Input Control Codes	4-11
4-9	Measurement Control Codes	4-12
4-10	Input Commands (Listener)	4-13
4-11	Special Function Codes	4-14
4-12	Alphabetic List of Command Codes	4-15
5-1	Control Logic Levels by Function.....	5-10



1.1 INTRODUCTION

1.1.1 The Racal-Dana Model 1993 universal counter/timer (UCT) is a microprocessor-controlled instrument offering high resolution measurements with a comprehensive range of capabilities. The 1993 can be provided with Option 41 Input C, extending frequency measurement to 1.3 GHz. It is a single card module compatible with the Wavetek 680 Multifunction System.

1.2 MEASUREMENT FUNCTIONS

1.2.1 Frequency A and B

1.2.1.1 Frequency A and B are used to measure the frequency of the signal applied to Inputs A and B, respectively. A resolution of 9 digits is available with a 1 second gate time.

1.2.2 Frequency C

1.2.2.1 Frequency C is available as Option 41. A resolution of 9 digits is available with a 1 second gate time.

1.2.3 Period A

1.2.3.1 Period A is used to measure the period of the waveform applied to Input A. A resolution of 9 digits is available with a 1 second gate time.

1.2.4 Time Interval

1.2.4.1 Time Interval provides single-shot measurements of the time interval between:

- a. Separate Mode: An event occurring at Input A and a later event at Input B
- b. Common Mode: Two events occurring at Input A

1.2.4.2 The arming of the stop trigger circuit can be delayed to prevent the measurement interval being stopped prematurely by spurious pulses, such as those caused by contact bounce.

1.2.5 Total A by B

1.2.5.1 Total A by B permits events occurring at Input A to be totalized. The counting interval can be controlled by:

- a. Electrical start and stop signals applied to Input B (Total A by B)
- b. Successive operations of a 680 front panel key or GPIB command accumulating counts (Manual Totalize)

1.2.5.2 Delayed arming of the stop circuit to prevent spurious triggering is available in the Total A by B mode.

1.2.6 Ratio A/B

1.2.6.1 Ratio A/B is used to measure the frequency ratio between Inputs A and B.

1.2.7 Ratio C/B

1.2.7.1 When Option 41 is installed, Ratio C/B is used to measure the frequency ratio between Inputs C and B.

1.2.8 Rise/Fall A

1.2.8.1 Rise Time A and Fall Time A are automatically measured using positive and negative slope selection, respectively.

1.2.9 Pulse Width A

1.2.9.1 Positive and negative Pulse Widths are automatically measured using positive and negative slope selection, respectively.

1.2.10 Phase A rel B

1.2.10.1 Phase A rel B is used to measure the phase difference between the waveform applied to Inputs A and B. The phase difference is displayed in degrees, and indicates the phase lead at Input A.

1.2.11 Peak Amplitude A and B

1.2.11.1 The auto-trigger function allows display of the positive and negative signal peaks for Inputs A and B.

1.2.12 Check

1.2.12.1 The Check function enables a number of functional tests of the instrument's circuits to be made without the use of additional test equipment. For example, the 1993 can measure the Model 680's 10-MHz internal reference standard. Although these tests do not check the instrument's performance to published specifications, they can be used to verify that the equipment is operating correctly following receipt or transportation to a new location. The Check function can be extended using special functions (see Subsection 3.5.7) to provide a comprehensive range of self tests.

1.3 SIGNAL INPUT CHARACTERISTICS

1.3.1 Inputs A and B are fully independent, but provision is made for connection of Input A's signal into both channels (common mode). When this is done, Input B's socket is isolated from Channel B.

1.3.2 Both Inputs A and B are provided with independent controls to permit selection of:

- a. AC or DC input coupling
- b. 1 Mohm or 50 ohms input impedance
- c. X1 or X10 input attenuation

- d. Positive or negative-slope trigger
- e. Manual or automatic setting of input trigger level

1.3.2.1 The manually set trigger level is entered into an internal store.

1.3.2.2 The auto-trigger level is derived by measuring the positive and negative peaks of the input signal. If the peak-to-peak value exceeds 5.1 V, or if either peak is outside the range ± 5.1 V, the X10 attenuator is automatically switched in. The trigger level is then set to the mean of the measured value.

1.3.2.2.1 When operating in auto-trigger with the X10 attenuator in-circuit, the attenuator will be switched out if the peak-to-peak value is less than 4.6 V and both peak values are within the range ± 4.6 V.

1.3.3 An internal low-pass filter can be introduced to reduce the bandwidth of Input A to 50 kHz (nominal).

1.3.4 Input C has a nominal input impedance of 50 ohms and is AC-coupled. Protection against excessive signal levels is provided by a 5 V rms fuse in the input BNC connector.

1.4 MATH COMPUTATION

1.4.1 When the Math function is active, the displayed value is $(R-X) Y/Z$ where R is the measurement result and X, Y, and Z are values entered into stores within the instrument by the user. X is set to 0, Y and Z to 1 when the instrument is powered-on. By an appropriate choice of values for X, Y, and Z; offset, normalized, and scaled displays can be achieved.

1.5 AVERAGE MODE

1.5.1 When the Average Mode is enabled a sample of 100 measurements is taken and the mean value displayed by the 680. Average Mode is available for all measurement functions except Totalize.

1.6 SPECIAL FUNCTIONS

1.6.1 The 1993 provides a set of special functions, permitting extended measurements and capabilities. See Subsection 3.5.7 for details.

1.7 ERROR INDICATION

1.7.1 Certain errors in counter operation will result in the display of error codes. See Subsection 3.5.8 for details.

1.8 EXTERNAL ARMING

1.8.1 External arming of the start and stop trigger circuits for the measurement interval can be carried out by means of signals applied to a BNC connector. Combinations of internal and external arming can be selected by use of the appropriate special function.

1.9 SINGLE SHOT MEASUREMENT MODE

1.9.1 The 1993 provides the capability to make a single measurement and hold the reading indefinitely. A new measurement cycle is initiated using the start key on the 680 (F1).

1.10 GATE TIME AND RESOLUTION

1.10.1 Refer to Subsections 3.5.2 and 3.5.3 for details. In Frequency A and B, Frequency C, Period A, Ratio A/B and C/B functions, a gate time may be specified from the 680 front panel (Gate Time mode) or by the selected display resolution after entering the Resolution mode. The available gate time range is 200 μ s to 99.9 s.

1.10.2 In the Total A by B and Manual Totalize functions, the counting interval (i.e., gate time) is controlled by the time interval between the start and stop signals at Input B, or between pushes of the Start (F1) and Stop (F2) keys on the 680.

1.10.3 In Phase mode, the gate time is fixed and the display resolution is determined by the input signal frequency.

1.11 AVAILABLE OPTION

1.11.1 1.3 GHz Input C (Option 41)

1.11.1.1 Option 41 is the only option available for the 1993. It is factory-installed and provides the 1993 with high frequency measurement capability to 1.3 GHz.

1.12 SAFETY

1.12.1 The 1993 is designed to meet international safety requirements. Refer to the safety page "FOR YOUR SAFETY" immediately preceding the Table of Contents. Follow all **NOTES**, **CAUTIONS**, and **WARNINGS** to ensure personal safety and prevent damage to the instrument.

1.13 PRODUCT SUPPORT

1.13.1 Racal-Dana supports the 1993 with Product Engineering, Service, and Parts Departments. A complete listing of service centers and field representatives is provided on the last two pages of the manual.

1.14 SPECIFICATIONS

1.14.1 Table 1-1 lists the 1993 specifications. They specify the performance standards to which the instrument should be tested during any necessary calibration and/or servicing.

Table 1-1. 1993 Specifications

GENERAL DESCRIPTION	
The 1993 universal counter/timer provides the following measurement functions: frequency, frequency ratio, period, high-resolution time interval, rise/fall time, pulse width, phase, and totalize. System interface is via the Wavetek Model 680. Supplemental features include mathematical manipulation of measurements, averaging of 100 readings, and peak amplitude measurement. The frequency range of Inputs A and B is DC to 100 MHz (See Note below). Single-shot time interval resolution is 1 nanosecond; frequency/period resolution is 9 digits per second of measurement time. Trigger levels on Inputs A and B can be set via the front-panel keys of the Wavetek 680 or auto-trigger at the 50% point of the input waveform. Trigger levels can be shown on the 680 main display. Option 41 Input C, G plug-in board, provides frequency measurement from 40 MHz to 1.3 GHz.	
INPUT CHARACTERISTICS	
Inputs A and B	
Frequency Range:	
DC-Coupled	0 to 100 MHz
AC-Coupled	10 Hz to 100 MHz
Note: Input A frequency range is 0 to 160 MHz in the frequency and period functions.	
Input Impedance (X1, X10):	
High, Separate	1 Mohm shunted by 45 pF (nominal)
High, Common	1 Mohm shunted by 55 pF (nominal)
50 ohms, Separate and Common	50 ohms (nominal)
Sensitivity, Sine Wave (X1):	
	25 mV rms to 100 MHz 50 mV rms to 160 MHz (Input A Frequency function only)
Sensitivity, Pulse (X1):	
	75 mV p-p; 5 ns minimum width
Dynamic Range (X1):	
	75 mV to 5 V p-p; 0 to 50 MHz 75 mV to 2.5 V p-p; 50 to 100 MHz 150 mV to 2.5 V p-p; 100 to 160 MHz (Input A Frequency function only)

Table 1-1. 1993 Specifications (Continued)

Signal Operating Range (X1):	-5.1 VDC to +5.1 VDC
Input Attenuation:	X1 or X10, selectable
Damage Level:	
1 Mohm input impedance	X1: 260V (DC + AC rms), DC to 1.92 kHz $\frac{5 \times 10^5 \text{V rms}}{\text{Frequency (Hz)}}, 1.92 \text{ to } 100 \text{ kHz}$ 5V rms, >100 kHz X10: 260V (DC + AC rms), DC to 19.2 kHz $\frac{5 \times 10^6 \text{V rms}}{\text{Frequency (Hz)}}, 19.2 \text{ to } 100 \text{ kHz}$ 50V rms, 100 kHz
50 ohms input impedance	X1, X10: 5V rms, DC to 160 MHz
Triggering:	
Trigger Level	Automatic or manual selection in the +5.1 V to -5.1 V range (X1), +51 V to -51 V range (X10). Trigger level readout can be shown on main display. <u>Automatic mode:</u> trigger points are set halfway between the maximum and minimum measured values of the input signal. Input signal must be continuous, with lowest auto-trigger frequency being 50 Hz. Auto-trigger on a DC level is possible. Nominal auto-trigger time is 500 ms per input. Auto-trigger selection of the attenuator is automatic as follows: X1 selected if positive and negative peak amplitudes are $< \pm 4.6$ and the peak-peak amplitude is $< 4.6\text{V}$. X10 selected if positive and negative peak amplitudes are $> \pm 5.1$ or the peak-peak amplitude is $> 5.1 \text{ V}$. <u>Manual mode:</u> trigger levels can be entered via the keyboard, the increment/decrement buttons on the adjustment knob.
Trigger Level Setting	20 mV steps, nominal (X1) 200 mV steps, nominal (X10)
Trigger Level Accuracy	X1: $\pm 1\%$ reading $\pm 30 \text{ mV}$ relative to trigger level set X10: $\pm 1\%$ reading $\pm 300 \text{ mV}$

Table 1-1. 1993 Specifications (Continued)

Auto-Trigger Minimum Amplitude	150 mV p-p
Auto-Trigger Level Accuracy	± 30 mV relative to displayed reading
Read Peak Amplitude Accuracy	Frequency Range: DC, 50 Hz to 20 MHz X1: ± 50 mV ± 6% V p-p (sinewave) ± 40 mV ± 1% reading (DC) X10: ± 1% reading ± 500 mV ± 6% V p-p
Coupling:	AC or DC
Slope:	Positive or negative; independently selectable
Low-Pass Filter: (Input A only)	50 kHz (nominal)
Input Connections:	BNC sockets
Crosstalk (X1 at 100 MHz):	36 dB between channels, measured using 50 ohms input impedance

FREQUENCY MEASUREMENT (INPUTS A and B)

Range:	
Input A	6×10^{-4} Hz to 160 MHz
Input B	3×10^{-4} Hz to 100 MHz
LSD Displayed:	$\frac{10^{-9} \times \text{Frequency (See Definition)}}{\text{Gate Time}}$
Resolution:	$(\pm 2 \times \text{LSD}) \pm \frac{1.4 \times \text{Trigger Error} \times \text{Frequency}}{\text{Gate Time (See Definition)}}$
Accuracy:	± Resolution ± Timebase Error x Frequency

PERIOD A (PERIOD AVERAGE) MEASUREMENT

Range:	6.25 ns to 1.7×10^3 s
LSD Displayed:	$\frac{10^{-9} \times \text{Period (See Definition)}}{\text{Gate Time}}$
Resolution:	$(\pm 2 \times \text{LSD}) \pm \frac{1.4 \times \text{Trigger Error} \times \text{Period}}{\text{Gate Time (See Definition)}}$
Accuracy:	± Resolution ± Timebase Error x Period

Table 1-1. 1993 Specifications (Continued)

TIME INTERVAL MEASUREMENT	
Input Configuration:	
Separate:	Input A start/Input B stop, Input B start/Input A stop (via Special Function 21)
Common:	Input A start/Input A stop
Time Range:	-2 ns to 8×10^5 s (i.e., stop signal can occur up to 2 ns before the start signal)
Trigger Slopes:	Start, positive or negative Stop, positive or negative
LSD Displayed:	1 ns (100 ps using averaging)
Resolution:	$\pm$ LSD $\pm$ 1 ns rms $\pm$ Start Trigger Error $\pm$ Stop Trigger Error (See Definition)
Accuracy:	$\pm$ Resolution $\pm$ Timebase Error x TI $\pm$ Trigger Level Timing Error $\pm$ Trigger Level Setting Error $\pm$ 2 ns (i.e., differential channel delay error - See Definition)
TOTALIZE A BY B	
Input Channel:	Input A (100 MHz maximum frequency)
Maximum Rate:	10^8 events/s
Range:	1 to 10^{12} -1
Pulse Width:	5 ns minimum at trigger points
Start/Stop:	Input B (electrical) Start, positive: Stop, negative with positive pulse Start, negative; Stop, positive with negative pulse Hold button enabled by Special Function 61 (manual totalize)
LSD Displayed:	$\pm$ 1 count
Resolution:	LSD
Accuracy:	LSD

Table 1-1. 1993 Specifications (Continued)

FREQUENCY RATIO MEASUREMENT		
Ranges: Ratio A/B		
Input A	DC to 100 MHz	
Input B	DC to 100 MHz	
LSD Displayed:	$\frac{10 \times \text{Ratio}}{F_A \times \text{Gate Time}}$	
Resolution:	$\pm \text{LSD} \pm \frac{\text{Trigger Error B}}{\text{Gate Time}}$	
Accuracy:	$\pm \text{Resolution}$	
Note:	Higher frequency is assumed to be applied to Input A.	

RISE/FALL TIME*		
*requires a continuous signal.		
Rise Time (Default State):	Start:	positive slope, 10% trigger point
	Stop:	positive slope, 90% trigger point
Fall Time:	Start:	negative slope, 90% trigger point
	Stop:	negative slope, 10% trigger point
Input Channel:	Input A	
Range:	20 ns to 20 ms	
Minimum Pulse Height:	500 mV p-p	
Minimum Pulse Width:	20 ns at signal peaks	
LSD Displayed:	1 ns (100 ps using averaging)	
Resolution:	$\pm \text{LSD} \pm 1 \text{ ns rms} \pm \text{Start Trigger Error} \pm \text{Stop Trigger Error}$ (See Definition)	
Accuracy:	$\pm \text{Resolution} \pm \text{Trigger Level Timing Error} \pm \text{Trigger Level Setting Error at 10\% trigger point} \pm \text{Trigger Level Setting Error at 90\% trigger point} \pm 2 \text{ ns}$ (differential channel delay error - see Definition) $\pm \text{Timebase Error} \times \text{Rise/Fall Time}$	

Table 1-1. 1993 Specifications (Continued)

PULSE WIDTH*	
*requires a continuous signal	
Positive Pulse Width: (Default State)	Start: positive slope, 50% trigger point Stop: negative slope, 50% trigger point
Negative Pulse Width:	Start: negative slope, 50% trigger point Stop: positive slope, 50% trigger point
Input Channel:	Input A
Range:	5 ns to 20 ms
Minimum Pulse Height:	150 mV p-p
LSD Displayed:	1 ns (100 ps using averaging)
Resolution:	$\pm \text{LSD} \pm 1 \text{ ns rms} \pm \text{Start Trigger Error} \pm \text{Stop Trigger Error}$ (see Definition)
Accuracy:	$\pm \text{Resolution} \pm \text{Trigger Level Timing Error} \pm \text{Trigger Level Setting Error} \pm 2 \text{ ns}$ (differential channel delay error - see Definition) $\pm \text{Timebase Error} \times \text{Pulse Width}$
PHASE A RELATIVE TO B*	
*requires a continuous signal	
Range:	0.0° to 360°
LSD Displayed:	0.1° to 1 MHz 1° to 10 MHz 10° to 100 MHz
Resolution:	$\pm \text{LSD} \pm \frac{(\text{TI Resolution}) \times 360^\circ}{\text{Period A}}$
Accuracy:	$\pm \text{LSD} \pm \frac{(\text{TI Accuracy}) \times 360^\circ}{\text{Period A}}$

Table 1-1. 1993 Specifications (Continued)

MATH	
Applies to all counting/timing measurement functions. Note that the Math function is applied prior to the Statistics function.	
Display:	$\frac{\text{Reading} - X}{Z} Y$
	where X, Y, and Z are user-entered constants.
Constant (X, Y, or Z) Range:	$\pm 1 \times 10^{-9}$ to $\pm 10 \times 10^9$ to nine significant figures
Note: Any number exceeding this range will result in a displayed LIMIT ERROR.	
AVERAGE MODE	
Number of Samples:	100 measurements are accumulated and averaged for transmission. Adds one extra digit of resolution.
Note: The Average mode applies to all timing and counting functions except totalize.	
GATE TIME	
Range	200 μ s- 99.9 s
Resolution:	25.6 μ s
TIME INTERVAL DELAY	
Range:	200 μ s to 800 ms
Step Size:	25.6 μ s
Accuracy:	$\pm 50 \mu$ s $\pm 0.1\%$ reading
BASIC FREQUENCY STANDARD	
Internal Frequency:	Derived from Wavetek Model 680.
EXTERNAL ARMING	
Applicability:	All functions, except phase, pulse width, rise/fall time, can be armed using modes selected via special functions.
Input Signal:	
Amplitude	TTL
Minimum Start-Stop Arm Period	100 ns

Table 1-1. 1993 Specifications (Continued)

INTERFACE	
Standard:	Wavetek Model 680 interface.
Programmable Controls:	All functions, signal conditioning parameters, and setups.
Data Output Format:	
Normal Output mode	FF+/-D.DDDDDDDDDDE+/-DDCRLF Where: F represents ASCII characters identifying function; D is an ASCII digit; and the decimal point varies within the mantissa.
TEMPERATURE PERFORMANCE	
Operating Temperature:	0°C to 50°C
Storage Temperature:	-40°C to +70°C
DIMENSIONS	
These include 162 mm (6.38 in.) High x 29 mm (1.160 in.) Wide x 472 mm (18.597 in.) Deep	
WEIGHT	
Approximately 1.6 kg (3.5 lb)	
OPTION	
Option 41 1.3 GHz Input C	
Plug-in option extending the counter range to 1.3 GHz	
Frequency Range:	40 MHz to 1.3 GHz
Sensitivity, Sine Wave:	Better than 25 mV rms to 1.0 GHz Better than 75 mV rms to 1.3 GHz
Dynamic Range:	25 mV to 5 V rms to 1.0 GHz 75 mV to 5 V rms to 1.3 GHz
Impedance:	50 ohms (nominal), AC-coupled, VSWR-2:1 at 1 GHz
Maximum Operating Input:	1 V rms
Maximum Input: (without damage)	7 V rms (fuse-protected, located inside input BNC connector)

Table 1-1. 1993 Specifications (Continued)

Frequency C:

LSD:	$(1\text{ns}/\text{Gate Time}) \times \text{FREQ}$
Resolution:	$(1\text{ns}/\text{Gate Time}) \times \text{FREQ}$
Accuracy:	$\pm (\text{Resolution}) \pm (\text{Time Base Uncertainty}) \times \text{FREQ}$

Ratio C/B

LSD Displayed:	$\frac{640 \times \text{Ratio}}{F_C \times \text{Gate Time}}$
Resolution:	$\pm \text{LSD} \pm \frac{\text{Trigger Error B}}{\text{Gate Time}}$
Accuracy:	$\pm \text{Resolution}$

Note: Higher frequency is assumed to be applied to Input C.

DEFINITIONS AND NOTES

1. Resolution and Gate Time

- a. Refer to the table below. The gate time is set by the selected resolution in the frequency, period, ratio, and check functions. However, gate times may also be programmed in increments rounded to the nearest 25.6 μs using the range of 200 μs to 99.999 s. The default state is determined by the resolution selected (see table), and is 100 ms (8 digits) at power-on. Also, the gate time may be extended by:
 - one period of the input signal on Frequency B and Ratio A/B
 - two periods of the input signal on Frequency A and Period A
- b. The resolution of phase and totalize is determined by the input signal
- c. Time interval, rise/fall time, and pulse width measurements have the resolution determined by both the input signal and the resolution set

Table 1-1. 1993 Specifications (Continued)

Resolution (no. of selected digits) in Frequency, Period Ratio, and Check	Gate Time	Display	GPB Code
10	10 s	Default	SRS* 10
9	1 s		9
8	100 ms		8
7	10 ms		7
6	1 ms		6
5 } See	1 ms		5
4 } NOTE	1 ms		4
3 } NOTE	1 ms		3

NOTE:

Measurements of frequency, period, ratio, and check are averaged when these gate times are set.

*SRS = Store the Display Resolution

2. Trigger Error

Trigger Error equals $\frac{\text{SQR}(e_i^2 + e_n^2)}{\text{Input Slew Rate at Trigger Point}}$ seconds rms

where e_i = input amplifier rms noise (typically 150 μ VRMS in 160 MHz bandwidth)

where e_n = input signal rms noise in 160 MHz bandwidth

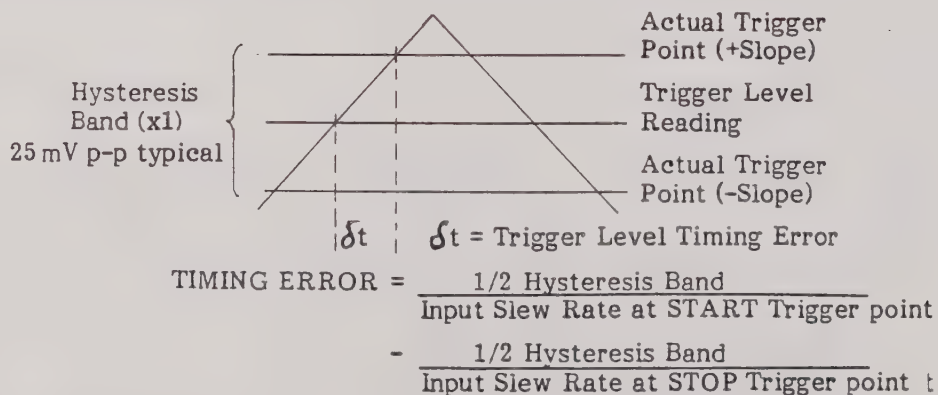
3. Trigger Level Timing Error (X1)

Table 1-1. 1993 Specifications (Continued)

4. Differential Channel Delay Error

A system error, typically less than 1 ns, but which can be compensated by numerical offset or by adjusting cable lengths.

5. Trigger Level Setting Error

a. In time interval:

$$\text{Setting Error} = \frac{\pm \text{Trigger Level Accuracy}}{\text{Input Slew Rate at Start Trigger Point}} \quad \frac{\pm \text{Trigger Level Accuracy}}{\text{Input Slew Rate at Stop Trigger Point}}$$

b. In rise/fall and pulse width:

$$\text{Setting Error} = \frac{\pm 60 \text{ mV}}{\text{Input Slew Rate at Trigger Point}}$$

6. Timebase Error

The fractional deviation of the timebase frequency from its nominal value due to aging, temperature, voltage variations, etc. (See the Wavetek Model 680 Manual for further details.)

2.1 INTRODUCTION

2.1.1 This section describes the unpacking and inspection, reshipment, installation, storage/temperature requirements, and functional check for the counter.

2.2 UNPACKING AND INSPECTION

2.2.1 Before unpacking the counter, check the exterior of the shipping carton for any signs of damage. All irregularities should be noted on the shipping bill. Remove the instrument carefully from its carton, preserving the factory packaging as much as possible. Inspect the counter for any defect or damage. Notify the carrier immediately if any damage is apparent. Have a qualified person check the instrument for safety before use.

2.3 RESHIPMENT INSTRUCTIONS

2.3.1 Use the original packaging if it is necessary to return the counter to Racal-Dana for calibration and/or servicing. The original shipping carton and the instrument's plastic-foam form will provide the necessary support for safe reshipment. If the original packaging is unavailable, reconstruct it as much as possible. Wrap the counter in plastic; then use plastic spray foam to surround and protect the instrument. Reship in either the original or a new, sturdy shipping carton.

2.4 1993 MODULE INSTALLATION

2.4.1 The following steps describe how to install the 1993 module into the Model 680 mainframe chassis:

- a. Remove the three screws from the rear of the 680 top panel and then slide this panel back and off.
- b. Place the 1993 module into the channel slots as shown in Figure 2-1. When inserting the 1993 into the slots, ensure the module guides slide into the top chassis alignment guides at either end of the module. Before setting the 1993 module in its channel slot, visually verify correct positioning.

2.5 STORAGE AND TEMPERATURE

2.5.1 The 1993 can be stored at temperatures ranging from -40°C to $+70^{\circ}\text{C}$ at 75% relative humidity without adverse effects to the module or its components. The counter must be brought within its specified operating range of 0°C to $+50^{\circ}\text{C}$ before power-on.

2.6 FUNCTIONAL CHECK

2.6.1 Introduction

2.6.1.1 The following test procedure confirms whether or not the 1993 is performing correctly by checking most of the counter's circuitry. The procedure should be conducted when the 1993 is first put into service and after shipment to a new location.

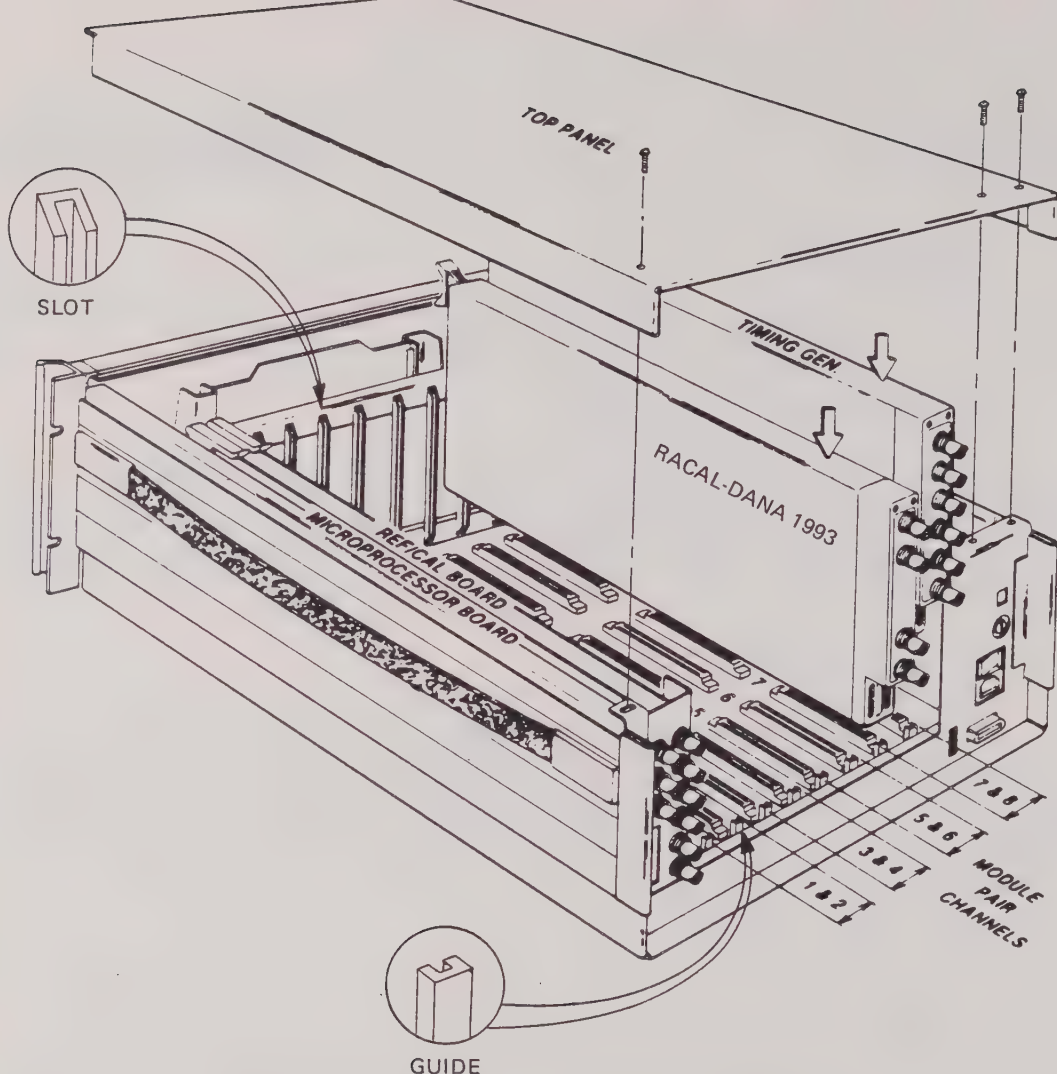


Figure 2-1. 1993 Module Installation

2.6.1.2 Perform the following procedure:

- a. Connect the 680 mainframe to a suitable AC power supply.
- b. Power-on the 680. Verify that "WAVETEK Model 680" is displayed for about two seconds. Press the **Select** key and choose the correct number for the 1993.
- c. Turn display on using key sequence read(F6), display(F2), and then on(F1).

NOTE:

Home-state conditions for the 1993 are listed in Subsection 3.2.3. Consult as required.

- d. Press the **Cal/Test** key, then select slftst(F2), then check(F3). Verify that the display shows 10.0000000 E6.
- e. Press key sequence **Menu**, datent(F5), resltn(F2), and sto_sf(F1). Using the adjustment knob, verify that the display resolution changes by one digit each time the knob is turned.

2.6.1.3 As required, the following additional tests may be performed using the 1993's special functions. Make sure the 1993 is in the Check mode before executing these tests.

- a. Provide two 50 ohms coaxial test leads fitted with BNC connectors.
- b. Lock the 10 MHz standard output of the Wavetek 680 to a pulse generator.
- c. Set up the pulse generator for a 10 MHz square wave, amplitude 0-02.2 V pk from an unterminated 50 ohms source.
- d. Connect the pulse generator to Channel A Input on the 1993. The cable should be approximately 1 m long.
- e. Press key sequence Menu datent(F5) spcfun(F4) sto_sf(F1) 77 Execute enbl(F4). This test verifies the proper operation of Input A's input relays. Confirm that the display shows 0.00000000.
- f. Disconnect the coaxial lead from Input A. The display should show an error number after a few seconds. See Table 3.4 for error codes.
- g. Using the same test lead, connect the pulse generator to the rear panel Input B connector.
- h. Press key sequence spcfun(F4) sto_sf(F1) 78 Execute enbl(F4). This test verifies the proper operation of Input B's input relays. Confirm that the display shows 0.00000000 as in step c.
- i. Disconnect the coaxial lead from Input B and the 10 MHz STD. OUTPUT BNC. The display should show Er 56.
- j. Turn the 1993 off.

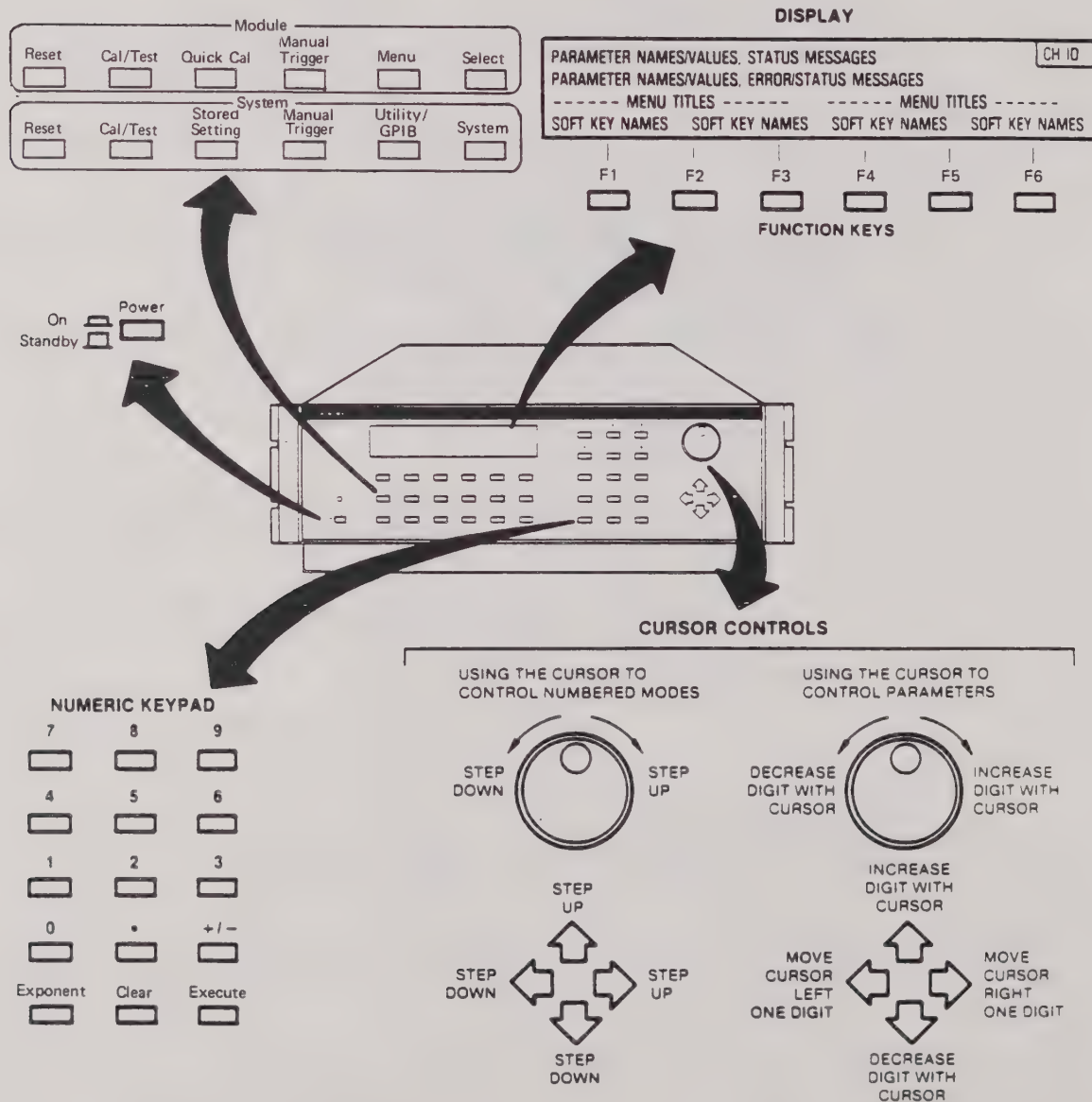


Figure 3-a. 680 Front Panel

3.1 INTRODUCTION

3.1.1 This section contains information for operating the 1993 as a bench instrument. It provides General Operating Information, Front Panel/Keyboard Organization, Measurement/Operating Procedures, and Miscellaneous Operating Information.

3.2 GENERAL OPERATING INFORMATION

3.2.1 If the counter is being used for the first time or at a new location, ensure that the voltage selector on the 680 unit is set for the correct local AC supply before turning on the instrument. Refer to the 680 Manual, as required, for details on line voltage selection.

3.2.2 Power-On and Self Test

3.2.2.1 Depress the Power-On/Standby button to its ON (⏻) position. Power should now be supplied to the entire 680.

3.2.2.2 After a brief self-test, the 680 will display the Model number (680) for approximately two seconds. Press the Select key in the Module section of the front panel and choose the correct slot number for the 1993 counter.

3.2.3 Home State

3.2.3.1 After self-test, the 1993 reverts to a home state, ready for operation. The following home-state conditions are selected after "self-test":

- a. Manual Trigger levels A and B: enabled
- b. Trigger levels A and B set to 0.00V, displayed levels are off
- c. Time Interval DELAY: set at 200 μ s (min. value), disabled
(Verify using key sequence Menu manfnc(F3) ti(F2) delay(F2) rcdly(F2))
- d. GATE Time: 100 ms (Resolution set to 8 digits)
(Verify using key sequence Menu datent(F5) resltn(F2) rclgt(F4))
- e. Math constants X, Y, and Z: 0, 1, 1, respectively, disabled

NOTE:

The user may set math constant Z to zero. However, any attempt to use the math function with this value set will cause the generation of an error code.

- f. Attenuation Input A and B: X1
- g. Input Impedance: 1 Megohm for Inputs A and B
- h. Separate inputs
- i. Filter: off

- j. Slopes A and B: positive
- k. Input coupling: AC for Inputs A and B
- l. Special Functions disabled (none stored)
- m. Hold: off

3.2.4 Main Display

3.2.4.1 Readings are displayed in engineering format with an 11-digit mantissa, a 2-digit exponent, and floating decimal point. The largest display reading is 999.9999999 with a +9 exponent; the smallest displayed reading is 1.000000000 with a -9 exponent.

3.2.4.2 See Subsections 3.5.2 and 3.5.3, and Table 3-2 for details of gate time and resolution. The selected function and resolution determine the number of digits displayed in the mantissa. In the frequency, period, frequency ratio, and check functions, 3 to 10 digits can be selected. Also, the gate time may be programmed in increments rounded to the nearest 25.6 μ s using the range of 200 μ s to 99.9 s. Stored gate times are immediately enabled.

3.2.4.3 Units in hertz, seconds, volts and degrees are implied.

3.3 FRONT PANEL/KEYBOARD ORGANIZATION

3.3.1 Refer to Table 3-1 and associated figures for the keyboard organization of the 680 front panel.

3.3.2 The Menu key allows you to control all functions of the 1993 Counter. See Figure 3-1 for a Menu flowchart.

Table 3-1. 680 Front-Panel Organization

Top Level	Second Level	Third Level	Screen Display/Description
[F1] chan_a			----- Channel A ----- filter couple impdnc slope attn trig F1 F2 F3 F4 F5 F6
	[F1] filter		Toggles a low-pass filter (50-kHz cutoff frequency) for input A.
		[F1] on	Turns filter on.
		[F2] off	Turns filter off.
	[F2] couple		Toggles Input A's coupling between DC and AC.
		[F1] dc	DC coupling.
		[F2] ac	AC coupling.
	[F3] impdnc		Toggles Input A's input impedance between 50 ohms and 1 megohm.
		[F1] 50 ohm	50 ohms input impedance.
		[F2] 1 Mohm	1 megohm input impedance.
	[F4] slope		Toggles Input A's trigger slope between positive and negative.
		[F1] pos	Positive trigger slope.
		[F2] neg	Negative trigger slope.
	[F5] attn		Toggles Input A's attenuation between X1 and X10.
		[F1] X1	Attenuation X1.
		[F2] X10	Attenuation X10.

Table 3-1. 680 Front-Panel Organization (Continued)

Top Level	Second Level	Third Level	Screen Display/Description
F2 chan_b	F6 trig		Toggles Input A's auto or manual triggering mode.
		F1 manual	Manual triggering.
		F2 auto	Auto-triggering.
		F3 store	In manual triggering, may use numeric keypad, cursor keys, or adjustment knob to store trigger level.
		F4 recall	Recall present trigger level.
	F1 couple		----- Channel B ----- couple impdnc slope attn trig sp/cm F1 F2 F3 F4 F5 F6
			Toggles Input B's coupling between DC and AC.
		F1 dc	DC Coupling.
		F2 ac	AC Coupling.
			Toggles Input B's input impedance between 50 ohms and 1 megohm.
		F1 50 ohm	50 ohms input impedance.
		F2 1 Mohm	1 megohm input impedance.
			Toggles Input B's trigger slope between positive and negative.
		F1 pos	Positive trigger slope.
		F2 neg	Negative trigger slope.
			Toggles Input B's attenuation between X1 and X10.
		F1 X1	Attenuation X1.
		F2 X10	Attenuation X10.
	F2 impdnc		
	F3 slope		
	F4 attn		

Table 3-1. 680 Front-Panel Organization (Continued)

Top Level	Second Level	Third Level	Screen Display/Description
F3 manfnc	F5 trig		Toggles Input B's auto or manual triggering mode.
		F1 manual	Manual triggering
		F2 auto	Auto-triggering
		F3 store	In manual triggering, may use numeric keypad, cursor keys, or adjustment knob to store trigger level.
	F6 sp/cm	F4 recall	Recall present trigger level.
		F1 sprt	Places Channels A and B in separate mode.
		F2 common	Connects Input A also to Input B (Input B isolated from BNC connector).
			-----Manual functions----- freq ti tot per_a rat_ab rat_c F1 F2 F3 F4 F5 F6
	F1 freq		Input A, B, or C frequency measurement.
		F1 ch_a	Input A frequency - measures frequency to 160 MHz, providing a resolution of at least 9 digits in 1 s.
		F2 ch_b	Input B frequency - measures frequency to 100 MHz, providing a resolution of at least 9 digits in 1 s.
		F3 ch_c	Input C frequency (Option 41) - measures frequency to 1.3 GHz with a resolution of at least 9 digits in 1 s.
	F2 ti		Time interval measurement. Intervals from -2 ns to 8×10^5 s can be measured.
		F1 sp/cm	F1 sprt - places Channels A and B in separate mode.
			F2 common- toggles Input A to Input B.

Table 3-1. 680 Front-Panel Organization (Continued)

Top Level	Second Level	Third Level	Screen Display/Description
		F2 delay	-- Time interval delay ----- strdly rcdly disdly endly F1 F2 F3 F4 F5 F6
			F1 strdly - allows user to store arming delay time using numeric keypad, cursor keys, or adjustment knob.
			F2 rcdly - recalls the present delay time.
			F3 disdly - disables arming delay time.
			F4 endly - enables arming delay time.
	F3 tot		Totalize (Input A events gated by Input B). Input A can totalize events at a rate up to 1×10^8 s.
		F1 ch__a	Allows user to set Channel A's parameters.
		F2 ch__b	Allows user to set Channel B's parameters.
		F3 strdly	Allows user to store arming delay time using numeric keypad, cursor keys, or adjustment knob.
		F4 rcdly	Recalls the present delay time.
		F5 disdly	Disables arming delay time.
		F6 endly	Enables arming delay time.
	F4 per_a		Input A period - measures period from 6.25 ns to 1.7×10^3 s, providing a resolution of up to 9 digits in 1 s.
	F5 rat_ab		Ratio of Frequency A to Frequency B, with frequency range of DC to 100 MHz.

Table 3-1. 680 Front-Panel Organization (Continued)

Top Level	Second Level	Third Level	Screen Display/Description
F4 autfnc	F6 rat_c		With Option 41 installed, measures ratio of Frequency C to Frequency B.
			Automatic functions - - - - - risfal pw_a phase F1 F2 F3 F4 F5 F6
	F1 risfal		Selects Rise/Fall Time for Input A, depending on the trigger slope condition. Input A Rise Time (positive slope; 10% start and 90% stop trigger points). Input A Fall Time (negative slope; 90% start and 10% stop trigger points). Changing either Input A or B trigger slope automatically changes the other input's slope. Minimum frequency is 50 Hz.
		F1 rise_a	Rise Time for Input A.
		F2 fall_a	Fall Time for Input A.
	F2 pw_a		Input A Pulse Width. Minimum frequency is 50 Hz.
		F1 pos_a	Positive pulse width measurement for Channel A.
		F2 neg_a	Negative pulse width measurement for Channel A.
	F3 phase		Phase difference (Input A relative to Input B).
		F1 ch__a	Allows user to set Channel A's parameters.
F5 datent		F2 ch__b	Allows user to set Channel B's parameters.
			- - - - - Data Entry - - - - - math resltn avrg spcfun F1 F2 F3 F4 F5 F6

Table 3-1. 680 Front-Panel Organization (Continued)

Top Level	Second Level	Third Level	Screen Display/Description
	F1 math		Math function $\frac{(R - X)Y}{Z}$
		F1 X	Allows user to store the value of X using numeric keypad, cursor keys, or adjustment knob.
		F2 Y	Allows user to store the value of Y using numeric keypad, cursor keys, or adjustment knob.
		F3 Z	Allows user to store the value of Z using numeric keypad, cursor keys, or adjustment knob.
		F4 enbl	Math function enabled.
		F5 dsbl	Math function disabled.
	F2 resltn		Permits resolution and gate-time adjustment.
		F1 sto_rs	Selects the number of display digits from 3 to 10 using numeric keypad, cursor keys, or adjustment knob. The gate time is disabled when the resolution is being stored.
		F2 rcl_rs	Allows user to recall the current resolution (number of display digits).
		F3 sto_gt	Allows user to store the gate time using numeric keypad, cursor keys, or adjustment knob.
		F4 rcl_gt	Allows user to recall the current gate time.
	F3 avrg		Allows user to activate the 100-reading average function.
		F1 on	Turns on the 100-reading average function.
		F2 off	Turns off the 100-reading average function.

Table 3-1. 680 Front-Panel Organization (Continued)

Top Level	Second Level	Third Level	Screen Display/Description
F6 read	F4 spcfun	F1 sto_sf	Selects special functions.
		F2 rcl_sf	Allows user to recall the stored special functions.
		F3 dsbl	Disables special functions.
		F4 enbl	Enables special functions.
	F1 mode	----- Read ----- mode displ gate recall F1 F2 F3 F4 F5 F6	
		F1 cont	Allows user to select between continuous and hold reading modes.
		F2 hold	Selects continuous reading mode.
			Selects hold reading mode.
	F2 displ		Allows user to turn on or off the measurement display.
		F1 on	Turns display on.
	F3 gate	F2 off	Turns display off.
		F1 start	Opens the gate to start manual totalize.
		F2 stop	Closes the gate to stop manual totalize.
		F3 counter reset	Resets the cumulative counter to zero during manual totalize.
		F4 read	Reads the counter's current total.

Table 3-1. 680 Front-Panel Organization (Continued)

Top Level	Second Level	Third Level	Screen Display/Description
	F4 recall		Allows user to recall unit model, motherboard(master software issue), and GPIB (software issue) numbers.
		F1 unit	Recalls the unit model number.
		F2 mobd	Recalls the motherboard (master software issue) number.
		F3 GPIB	Recalls the GPIB software issue number.

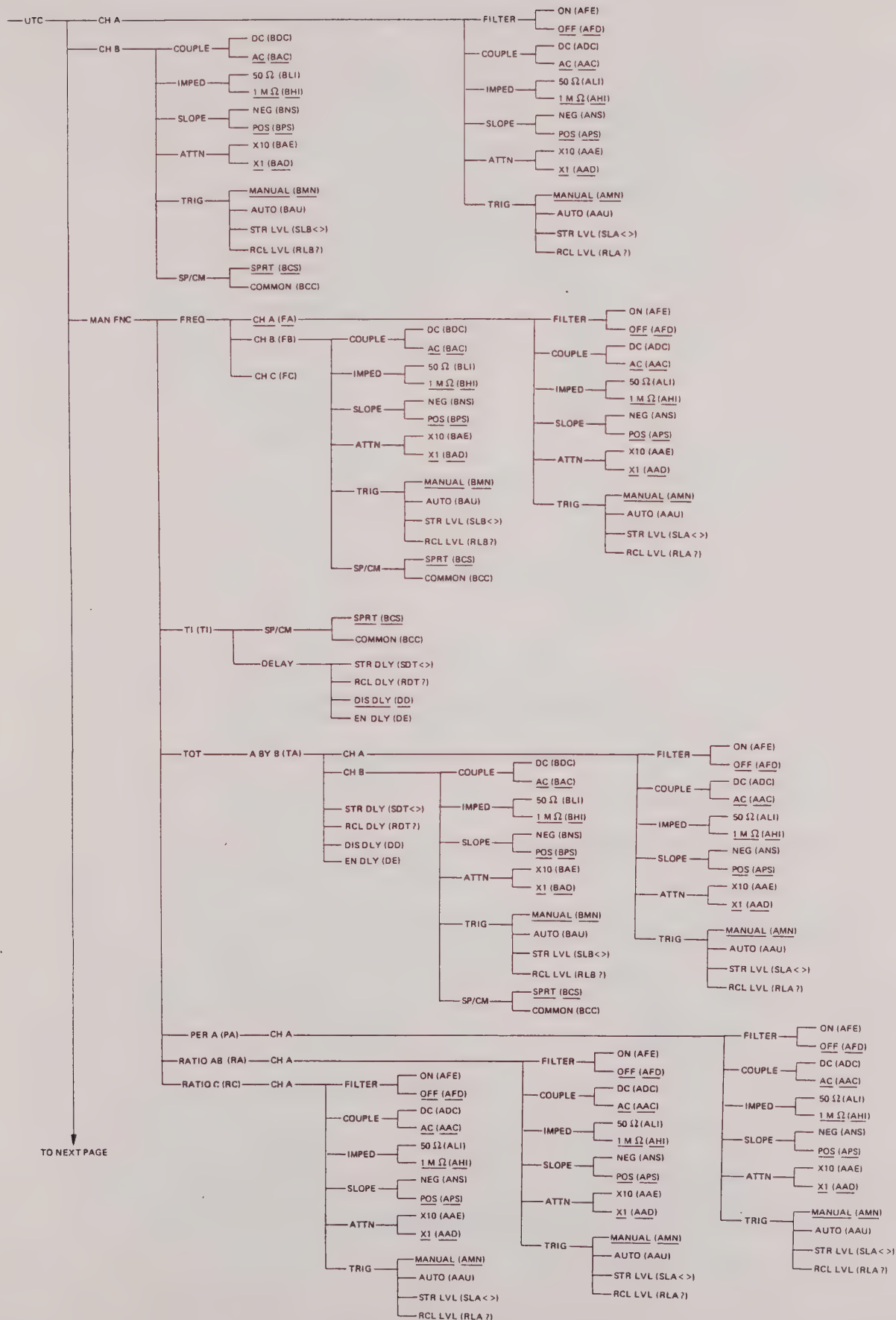


Figure 3-1. 1993 Menu Flowchart

FROM PREVIOUS PAGE

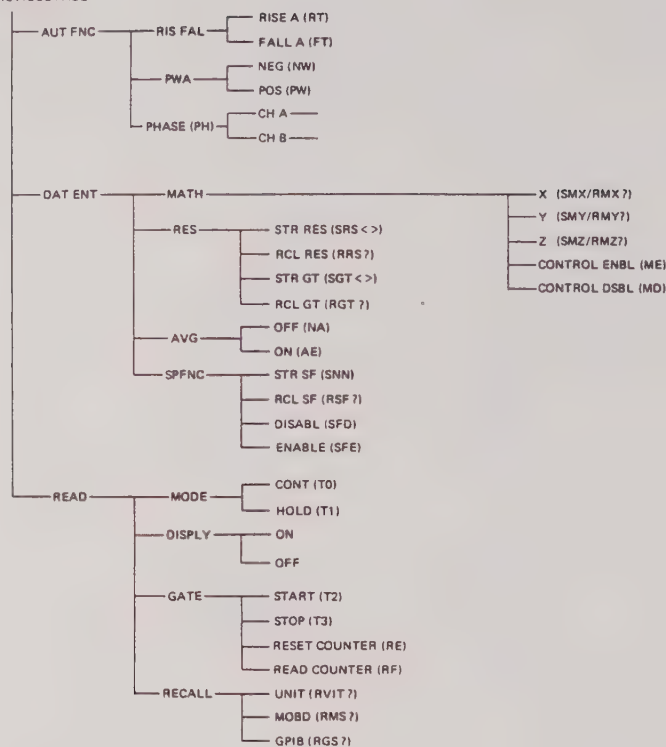


Figure 3-1. 1993 Menu Flowchart (Continued)

3.4 MEASUREMENT AND OPERATING PROCEDURES

3.4.1 Frequency Measurement

3.4.1.1 Complete the following procedure:

- a. Turn power on.
- b. Press Select.
- c. Choose the correct module slot number using the numeric keypad for counter.
- d. Select read(F6).
- e. Select disp(F2) to enter measurement display mode.
- f. Turn display on(F1).
- g. Press Menu to return to main menu.
- h. Select manfnc(F3) for manual functions.
- i. Select freq(uecy)(F1).

- j. Connect the measurement signal to Input A (topmost connector at rear of unit).
- k. Select `ch_a(F1)` and set all required settings.
- l. If a frequency below 50 kHz is to be measured in the presence of high-frequency noise, select `filter(F1)` and turn it on(F1).
- m. Press `Menu` to return to main menu.

3.4.2 Period Measurement

3.4.2.1 Complete the following procedure:

- a. Turn power on.
- b. Press `Select`.
- c. Choose the correct number using the numeric keypad for counter.
- d. Select `read(F6)`.
- e. Select `disply(F2)` to enter measurement display mode.
- f. Turn display on(F1).
- g. Press `Menu` to return to main menu.
- h. Select `manfnc(F3)` for manual functions.
- i. Select `per_a(F4)` for Period A.
- j. Connect the measurement signal to Input A (topmost connector at rear of unit).
- k. Set `filter(F1)`, `AC/DC coupling(F2)`, `input impedance(F3)`, and `attenuation(F5)` as required.
- l. The trigger level automatically defaults to auto-trigger. Refer to manual trigger level setting (Subsection 3.4.11) to set trigger level manually.
- m. Press `Menu` to return to main menu.

3.4.3 Time Interval Measurement

3.4.3.1 Complete the following procedure:

- a. Turn power on.
- b. Press `Select`.
- c. Choose the correct number using the numeric keypad for counter.

- d. Select read(F6).
- e. Select disp(F2) to enter measurement display mode.
- f. Turn display on(F1).
- g. Press Menu to return to main menu.
- h. Select manfnc(F3) for manual functions.
- i. Select ti(F2) for Time Interval.
- j. Select sp/cm(F1) for separate or common mode.
- k. Select sprt(F1) for separate or common(F2) for common mode.
- l. Press Menu to return to main menu.
- m. Select chan_a(F1) and set all required settings.
- n. Press Menu to return to main menu.
- o. Select chan_b(F2) and set all required settings.
- p. Connect measurement signals.
- q. Press Menu to return to main menu.

3.4.4 Manual Totalize Measurement

3.4.4.1 Complete the following procedure:

- a. Turn power on.
- b. Press Select.
- c. Choose the correct number using the numeric keypad for counter.
- d. Select read(F6).
- e. Select disp(F2) to enter measurement display mode.
- f. Turn display on(F1).
- g. Press Menu to return to main menu.
- h. Select chan_a(F1) and set all required settings.
- i. Press Menu to return to main menu.
- j. Select datent(F5) for data entry.
- k. Select spcfun(F4) for special functions.

- l. Select sto_sf(F1) to permit storage of special functions.
- m. Using the numeric keypad, enter Special Function 61 either by key sequence 61 **Execute** , or turn adjustment knob until number 61 appears on display and press **Execute**.
- n. Select enbl(F4) to enable special functions.
- o. Press **Menu** to return to main menu.
- p. Select manfnc(F3) for manual functions.
- q. Select tot(F3) for Totalize.
- r. Select ch_a(F1).
- s. Connect the measurement signal.
- t. Press **Menu** to return to main menu.
- u. Select read(F6).
- v. Select gate(F3).
- w. Control the gate by using start(F1) and stop(F2) keys.
- x. Press read(F4) to display current Totalize measurement. This displayed result is cumulative over successive measurement cycles. Use counter reset(F3) to clear the display and reset counter to zero.

3.4.5 Ratio A/B Measurement

3.4.5.1 Complete the following procedure:

- a. Turn power on.
- b. Press **Select**.
- c. Choose the correct number using the numeric keypad for counter.
- d. Select read(F6).
- e. Select disply(F2) to enter measurement display mode.
- f. Turn display on(F1).
- g. Press **Menu** to return to main menu.
- h. Select chan_a(F1) and chan_b(F2) and set all required settings.
- i. Press **Menu** to return to main menu.
- j. Connect the measurement signals to Inputs A and B at rear of the unit.

- k. Select manfnc(F3) for manual functions.
- l. Select rat_ab(F5) for Ratio A/B.
- m. Press **Menu** to return to main menu.

3.4.6 Rise/Fall A Measurement

3.4.6.1 Complete the following procedure:

- a. Turn Power on.
- b. Press **Select**.
- c. Choose the correct number using the numeric keypad for counter.
- d. Select read(F6).
- e. Select disp1y(F2) to enter measurement display mode.
- f. Turn display on(F1).
- g. Press **Menu** to return to main menu.
- h. Select chan_a(F1) and set all required settings.
- i. Press **Menu** to return to main menu.
- j. Select autfnc(F4) for auto-functions.
- k. Select risfal(F1) for Rise/Fall Time for Input A.
- l. Choose between rise_a(F1) and fall_a(F2).
- m. Connect measurement signal to Input A.
- n. Press **Menu** to return to main menu.

3.4.7 Pulse Width A Measurement

3.4.7.1 Complete the following procedure:

- a. Turn power on.
- b. Press **Select**.
- c. Choose the correct number using the numeric keypad for counter.
- d. Select read(F6).
- e. Select disp1y(F2) to enter measurement display mode.
- f. Turn display on(F1).

- g. Press **Menu** to return to main menu.
- h. Select **chan_a(F1)** and set all required settings.
- i. Press **Menu** to return to main menu.
- j. Select **autfnc(F4)** for auto-functions.
- k. Select **pw_a(F2)** for Pulse Width A.
- l. Select either **pos_a(F1)** or **neg_a(F2)** for positive or negative pulse widths, respectively.
- m. Connect measurement signal to Input A.
- n. Press **Menu** to return to main menu.

3.4.8 Phase A rel B Measurement

3.4.8.1 Complete the following procedure:

- a. Turn power on.
- b. Press **Select**.
- c. Choose the correct number using the numeric keypad for counter.
- d. Select **read(F6)**.
- e. Select **disply(F2)** to enter measurement display mode.
- f. Turn display on(F1).
- g. Press **Menu** to return to main menu.
- h. Select **chan_a(F1)** and **chan_b(F2)** and set AC/DC coupling, input impedance, and slopes as required. Selected slopes for input signals A and B should be the same.
- i. Press **Menu** to return to main menu.
- j. Select **autfnc(F4)** for auto-functions.
- k. Select **phase(F3)** for Phase A and rel B.
- l. Select **ch_a(F1)** and **ch_b(F2)** to set up required input conditions.
- m. Connect measurement signals to Inputs A and B.
- n. Press **Menu** to return to main menu.

3.4.9 Gate-Time Setting

3.4.9.1 Complete the following procedure:

- a. Press **Menu** to go to main menu.
- b. Select datent(F5) for data entry.
- c. Select resltn(F2) for resolution.
- d. Select sto_{gt}(F3) to permit storage of gate time.
- e. Set gate time using either the adjustment knob or numeric keypad, then press **Execute**. For example, use key sequence 200 **Exponent** **+/-** **6** **Execute** to set a 200-us gate time.
- f. Press **Menu** to return to main menu.

3.4.10 Resolution Setting

3.4.10.1 Complete the following procedure:

- a. Press **Menu** to go to main menu.
- b. Select datent(F5) for data entry.
- c. Select resltn(F2) for resolution.
- d. Select sto_{rs}(F1) to store resolution.
- e. Use adjustment knob to specify the number of display digits (resolution) required.
- f. Press **Menu** to return to main menu.

3.4.11 Manual Trigger Level Setting

3.4.11.1 Complete the following procedure:

- a. Press **Menu** to go to main menu.
- b. Select chan_a(F1) or chan_b(F2).
- c. Select trig(F6).
- d. Select manual(F1) for manual triggering.
- e. Select store(F3).
- f. Set the trigger level using either the adjustment knob, or numeric keypad and entering the level followed by pressing the **Execute** key.
- g. Press **Menu** to return to main menu.

3.4.12 Auto-Triggering Level Recall

3.4.12.1 Assuming that measurements are being displayed and Auto-Trigger mode is enabled, complete the following procedure:

- a. Select chan_a(F1).
- b. Select trig(F6) for trigger level.
- c. Select recall(F4). The top row of the screen displays the trigger level set by the auto-trigger function (50% point of the signal's peak-to-peak amplitude).
- d. Press Menu to return to main menu.
- e. Select chan_b(F2).
- f. Select trig(F5) for trigger level. The top row of the screen displays the trigger level set by the auto-trigger function (50% point of the signal's peak-to-peak amplitude).

3.4.13 50-Ohm Impedance Selection

3.4.13.1 Complete the following procedure:

- a. Press Menu to go to main menu.
- b. Select either chan_a(F1) or chan_b(F2).
- c. Select impdnc(F3) for impedance.
- d. Select 50 ohm(F1).
- e. Press Menu to return to main menu.

3.4.14 Positive/Negative Slope Selection

3.4.14.1 Complete the following procedure:

- a. Press Menu to go to main menu.
- b. Select either chan_a(F1) or chan_b(F2).
- c. Select slope (F4 for chan_a, F3 for chan_b).
- d. Select either pos(itive) slope(F1) or neg(ative) slope(F2).
- e. Press Menu to return to main menu.

3.4.15 AC/DC Coupling Selection

3.4.15.1 Complete the following procedure:

- a. Press Menu to go to main menu.

- b. Select either chan_a(F1) or chan_b(F2).
- c. Select couple (F2 for chan_a, F1 for chan_b).
- d. Select either ac(F2) or dc(F1) coupling.
- e. Press Menu to return to main menu.

3.4.16 Peak Voltage Level Recall

3.4.16.1 Complete the following procedure:

- a. Press Menu to go to main menu.
- b. Select datent(F5) for data entry.
- c. Select spcfun(F4) for special functions.
- d. Select sto_sf(F1) to permit storage of special functions.
- e. Using the numeric keypad on adjustment knob, enter Special Function 51 (for positive peak amplitude) or Special Function 52 (for negative peak amplitude).
- f. Select enbl(F4) to enable special functions.
- g. Press Menu to return to main menu.
- h. Select either chan_a(F1) or chan_b(F2).
- i. Select trig(F6) for trigger.
- j. Select recall(F4) to display maximum / minimum voltage level.

3.4.17 X, Y and Z Constant Storage

3.4.17.1 Complete the following procedure:

- a. Press Menu to go to main menu.
- b. Select datent(F5) for data entry.
- c. Select math(F1).
- d. Select x(F1), y(F2) or z(F3) as required.
- e. Store constant using key sequence n Execute where n is the constant value.
- f. Select enbl(F4) to enable math function.
- g. Press Menu to return to main menu.

3.4.18 Separate/Common Mode Selection

3.4.18.1 Complete the following procedure:

- a. Press **Menu** to go to main menu.
- b. Select chan_b(F2).
- c. Select sp/cm(F6) for separate or common mode.
- d. Select sprt(F1) for separate or common(F2) for common mode.
- e. Press **Menu** to return to main menu.

3.4.19 Attenuation Level Setting

3.4.19.1 Complete the following procedure:

- a. Press **Menu** to go to main menu.
- b. Select chan_a(F1) or chan_b(F2).
- c. Select attn (F5 for chan_a, F4 for chan_b) for attenuation level.
- d. Select X1(F1) or X10(F2).
- e. Press **Menu** to return to main menu.

3.4.20 Filter Selection

3.4.20.1 Complete the following procedure:

- a. Press **Menu** to go to main menu.
- b. Select chan_a(F1).
- c. Select filter(F1).
- d. Select on(F1) to turn on the filter.
- e. Press **Menu** to return to main menu.

3.4.21 Auto-Trigger

3.4.21.1 Complete the following procedure:

- a. Press **Menu** to go to main menu.
- b. Select chan_a(F1) or chan_b(F2).
- c. Select trig (F6 for chan_a, F5 for chan_b) for trigger.

- d. Select auto(F2) to enable Auto-Trigger mode.
- e. Press **Menu** to return to main menu.

3.4.22 Check Mode Entry

3.4.22.1 Complete the following procedure:

- a. Press **Cal/Test** on front panel.
- b. Press slftst(F2) for self-test selection.
- c. Select check(F3) to enter Check mode.
- d. Press **Menu** to return to main menu.

3.5 MISCELLANEOUS OPERATING INFORMATION

3.5.1 Trigger Level Setting

3.5.1.1 Introduction

3.5.1.1.1 The 1993 provides both manual and automatic (including single-shot) trigger setting for Inputs A and B. Trigger level readout is available on the top line of the display.

3.5.1.1.2 Manual trigger selection involves setting the levels in either the ± 5.1 V or ± 51 V ranges, with corresponding resolutions of 20 mV and 200 mV. These ranges correspond to attenuation settings of X1 and X10. Any valid trigger entry, having more than 3 digits will be entered, but truncated to just 3 digits when stored as a trigger level. For example, 4.6432 V becomes 4.64 V (X1), or 4.6 V (X10). Also, the trigger level operates in 20 mV (X1) and 200 mV (X10) steps with all entries being rounded up. For example, 1.3754 V becomes 1.38 V (X1) and 1.4 V (X10).

3.5.1.1.3 Auto-trigger level is the mean of the positive and negative-peak values of the input signal as determined automatically by the counter.

3.5.1.2 Manual Trigger Setting

NOTE:

An attenuation setting of X1 and a trigger level of 1.24 volts for Channel A are assumed in the following description.

3.5.1.2.1 Set the trigger level manually using one of the following key sequences:

- a. To set a trigger level of +1.24, use **Menu** chan_a(F1) trig(F6) manual(F1) store(F3) 1.24 **Execute**.
- b. To set a trigger level of -1.24, use **Menu** chan_a(F1) trig(F6) manual(F1) store(F3) +/- 1.24 **Execute**.

3.5.1.2.2 Use key sequence **Menu** chan_a(F1)/chan_b(F2) trig(F6) recall(F4) to display Input A/B's current trigger level.

3.5.1.2.3 Press the Menu key again to return the counter to the main menu.

3.5.1.2.4 Any manual trigger level that is out-of-range will produce "Trigger level: limit error" display message. For example, entering 47.2 V as a trigger level in X1 attenuation will generate "Trigger level: limit error" display message. The user should then press the Menu key to return to the main menu, select appropriate channel, and select X10 attenuation, and reenter 47.2 V following the previous instructions. This new trigger level may be stored or changed.

NOTE:

Inputs A and B each have a single trigger-level store. Use of the Auto-Trigger mode overwrites a manually stored trigger setting. Also, pressing the auto key(F2) while manually setting the trigger level enables the Auto-Trigger mode. Toggle the manual key(F1), then enter a manual trigger level.

3.5.1.3 Auto-Trigger Setting

3.5.1.3.1 Press the required auto key(F2) to calculate and set the auto-trigger level. Automatic attenuation occurs in the Auto-Trigger mode.

3.5.1.3.2 Press the corresponding recall key(F4) to display the current auto-trigger level.

3.5.1.4 Single-Shot Auto-Trigger

3.5.1.4.1 Auto-trigger settings vary as peak input levels change. To execute and store a single-shot auto-trigger level:

- a. Store Special Function 31 using key sequence Menu datent(F5) spcfun(F4) sto_sf(F1)31 Execute.
- b. Enable special functions by pressing enbl(F4).

3.5.1.4.2 The stored level is retained as a manually set value until either (1) another single-shot measurement is made, or (2) a new manual trigger level is entered.

3.5.1.4.3 To execute additional single-shot trigger settings, press the auto key(F2) again with Special Function 31 enabled.

3.5.1.5 Automatic Attenuation Setting

3.5.1.5.1 When operating in the Auto-Trigger mode, automatic switching of the X10 attenuator occurs as follows:

- a. The X10 attenuator is selected if the peak-to-peak value of the input signal exceeds 5.1 V or if either peak is outside the range ± 5.1 V.
- b. The attenuator is deselected if the peak-to-peak value of the input signal is less than 4.6 V and both peaks are within the range ± 4.6 V.

3.5.2 Display Resolution

3.5.2.1 In the 1993, resolution of totalize and phase measurements is determined by the input signal. (Resolution of time interval, rise/fall, and pulse width is determined by both the resolution set and input signal.) For all other functions, the resolution is determined by the resolution set.

3.5.2.2 The 1993's resolution can be set to any value from 3 to 10 digits. A 10% overrange of the counter's display occurs without a change of range.

3.5.2.3 Results are rounded to meaningful values in all measurement functions. Therefore, the number of displayed digits may be less than the selected resolution. For example, in the time-interval function, the resolution may be selected down to 3 digits (100 ns); however, the 1993 will display only 1 digit when measuring down to 0 ns.

3.5.2.3.1 In frequency ratio, a maximum of 7 digits are displayed regardless of the selected resolution.

3.5.2.3.2 In phase, a maximum of 4 digits are displayed for frequencies to 1 MHz; 3 digits for higher frequencies. For frequencies above 10 MHz, the display resolution is 10^0 with a place-holding zero displayed as the least-significant digit.

3.5.2.4 Display Resolution Setting

3.5.2.4.1 Display resolution for the 1993 is function-dependent and is set using the key sequence Menu datent(F5) resltn(F2) sto_rs(F1), and then the adjustment knob to select the number of display digits from 3 to 10. This permits the user to select the number of display digits from 3 to 10.

3.5.3 Gate Time

3.5.3.1 Refer to Table 3-2. In frequency, period, ratio, and check functions, the gate time is set by the selected resolution.

Table 3-2. Resolution and Gate Time

Resolution (no. of selected digits) in Frequency, Period, Ratio, and Check-See NOTE	Gate Time	Display	GPIB Code
10	10 s	Up Stop	SRS* 10
9	1 s		9
8	100 ms	Default	8
7	10 ms		7
6	1 ms		6
5 } See	1 ms		5
4 } NOTE	1 ms		4
3 }	1 ms	Down Stop	3
NOTE: Measurements of frequency, period, ratio, and check are averaged when these gate times are set. *SRS=Store Display Resolution Command			

3.5.3.2 Gate Time Storage/Recall

3.5.3.3 Use key sequences **Menu** datent(F5) resltn(F2) sto_gt(F3) <value> **Execute** and **Menu** datent(F5) resltn(F2) rcl_gt(F4) to store and recall gate times, respectively.

3.5.3.4 The default state is determined by the resolution selected (see Table 3-2); the home state resolution is 8 digits or a 100-ms gate time.

3.5.3.5 Also, gate times may be programmed in increments rounded to the nearest 25.6 μ s using the range of 200 μ s to 99.9 s. Whenever the counter is not in the Resolution mode and gate times are being set directly, the display resolution is dependent on the input signal's frequency/time and gate time.

3.5.3.6 Gate time may be extended over the programmed value as follows:

- a. One period of the input signal on FREQ B, RATIO A/B
- b. Two periods of the input signal on FREQ A, PERIOD A

3.5.3.7 When the counter's gate time is programmed, it is immediately enabled. Adjusting the resolution will disable the gate time which reverts to the nearest decade.

3.5.4 Stop Arm Delay (Hold Off)

3.5.4.1 The arming of the stop input circuit may be delayed or held off when either the TI A→B or TOTAL A by B function is selected. The programmable delay range is 200 μ s to 99.9 s, with the display rounded to the nearest 25.6 μ s. In the home state, the delay function is set at its minimum value of 200 μ s.

3.5.4.2 The stop arm delay can be useful in preventing premature triggering of the stop circuit by spurious signals (e.g., those resulting from relay contact bounce). Figure 3-2 shows the principle of the stop arm delay.

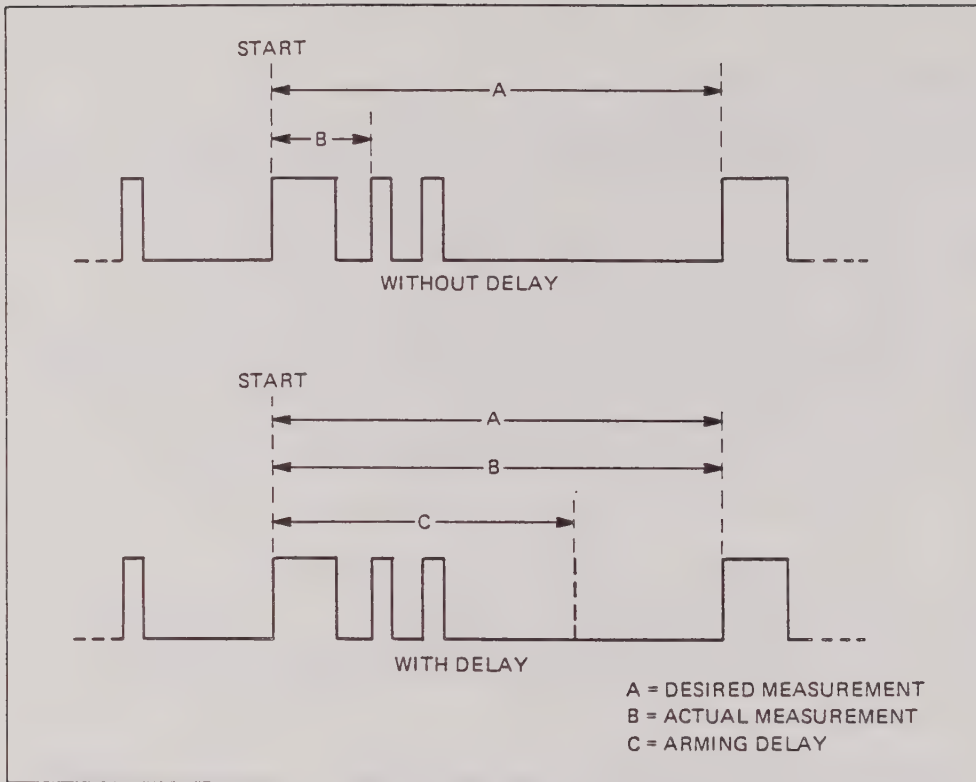


Figure 3-2. Use of Stop Arm Delay

3.5.4.3 Stop Arm Delay Storage

3.5.4.3.1 A stop arm delay is stored using key sequence **Menu** manfnc(F3) ti(F2) delay(F2) strdly(F1) <value> **Execute** endly(F4) where <value> is in decimal or exponential form.

3.5.4.3.2 The value of the displayed delay entered is rounded to the nearest 25.6 us before it is stored. Attempted entry of an out-of-range value will result in an "limit error" being displayed. The counter returns to the measurement mode automatically once the delay value is entered.

3.5.4.4 Stop Arm Delay Recall

3.5.4.4.1 Recall stored delay values to the display using key sequence **Menu** manfnc(F3) ti(F2) delay(F2) rcldly(F2).

3.5.4.5 Stop Arm Delay Enabling/Disabling

3.5.4.5.1 Enable and disable the stop arm delay by successively using key disdly(F3)/endly(F4).

3.5.5 Math Function (R-X) Y/Z

3.5.5.1 The math function applies to all counting and timing functions of the 1993 except phase measurement and check. This function permits the measurement reading (R) to be offset, normalized, or scaled before display, using stored constants X, Y, and/or Z, respectively. The display indicates (R-X) Y/Z after enabling the math function. Home state values for X, Y, and Z are 0, 1, and 1, respectively (Z ≠ 0 at any time).

3.5.5.2 Math Constant Storage/Recall

3.5.5.2.1 Constants X, Y and/or Z must be stored before enabling the math function. Use key sequence **[Menu]** datent(F5) math(F1) X(F1) <value> /Y(F2) <value> /Z(F3) <value> **[Execute]**, where <value> is in decimal or exponential form, to enter constants X, Y, or Z. +1E-9 to +10E9 to nine significant digits. Any number exceeding this range will result in "limit error" message being displayed. The actual display range to verify for the 1993 is +999.999999 E+9. Use key sequence **[Menu]** datent(F5) math(F2) X(F1)/Y(F2)/Z(F3) to recall the math constants.

3.5.5.3 Math Function Enabling/Disabling

3.5.5.3.1 Enable and disable the math function by successively using key sequence **[Menu]** datent(F5) math(F1) enbl(F4)/math(F1) dsbl(F5).

3.5.6 100 Average Function

3.5.6.1 This function permits the counter to accumulate 100 measurements and display the averaged result. The function may be applied to all counting and timing functions of the 1993 except totalize. Resolution is improved by one display digit (one decade). Any number exceeding the display range will produce an error message.

3.5.6.2 100 Average Function Enabling/Disabling

3.5.6.2.1 Enable and disable the 100 Average function by successively using key sequence **[Menu]** datent(F5) avrg(F3) on(F1)/off(F2).

3.5.7 Special Functions

3.5.7.1 Table 3-3 lists the special functions available on the 1993. All special functions are designated by a two-digit special function number (nn). Special functions are organized by decades, one for each of the nine mantissa display digits. One special function at a time from each decade can be entered into the special function register.

3.5.7.2 Special Function Storage

3.5.7.2.1 Special function numbers must be entered into memory before special functions can be enabled. Use the following key sequence to store, for example, Special Function 21: **[Menu]** datent(F5) spcfun(F4) sto_sf(F1) 21 **[Execute]**.

3.5.7.2.2 The digits for a special function number are shown on the display as the numeric keys are pressed. Once the number is stored, the counter automatically returns to the measurement mode.

3.5.7.2.3 When a number is stored, it overwrites the number stored in the same decade. Therefore, to remove a number from its register, another number from the same decade must be stored.

3.5.7.3 Special Function Recall

3.5.7.3.1 Stored special functions are recalled for display using key sequence **[Menu]** datent(F5) spcfun(F4) rcl_sf(F2). Only the decade is indicated by the position of the digit in the register and the second digit is displayed. Default state has a 0 entered in each position. Refer to Figure 3-3 for a typical special functions display.

3.5.7.4 Special Function Enabling/Disabling

3.5.7.4.1 The power-on home state for special functions is that none are stored. Default state then corresponds to the special function register, with all digits displaying zero. Successively use key sequence Menu datent(F5) spcfun(F4) enbl(F4)/dsbl(F3) to enable and disable stored special functions.

NOTE:

Storing a special function when special functions are enabled, immediately enables that special function.

Table 3-3. Special Functions (SFs)

SF Number	Function		
		<u>Start</u>	<u>Stop</u>
10 } 11 } 12 } 15 } Arming 16 } 17 } 18 }	<u>Default:</u>	Internal External+ve External-ve External+ve External+ve External-ve External-ve	Internal Internal Internal External+ve External-ve External+ve External-ve
20 21	<u>Default:</u>	Normal Operation Inputs A and B interchanged. Permits PERIOD B and TI B → A measurements, for example. <u>See NOTE 1 below:</u>	
30 31	<u>Default:</u>	Continuous auto-trigger measurement Single-shot auto-trigger measurement	
50 51 52	<u>Default:</u>	Trigger level Signal positive peak Signal negative peak	
60 61	<u>Default:</u>	Totalize A by B Manual Totalize	
70 72 73 74 75 76 77 78	<u>Default:</u> Diagnostic Testing	Basic 10 MHz Check/Press Cal/Test slftst(F2) check(F3) sequence. Start TEC short continuous calibration (100-ns pulse applied); display shows TEC count Start TEC long continuous calibration (200-ns pulse applied); display shows TEC count Stop TEC short calibration Stop TEC long calibration Input A and B DAC Check-continuously ramps through DACs Input A relay check/Press Cal/Test slftst(F2) check(F3) sequence. Input B relay check/Press Cal/Test slftst(F2) check(F3) sequence. <u>See NOTE 2 below:</u>	
<u>NOTE 1:</u>		In Special Function 21, Frequency B is specified to 100 MHz only; Period B is specified to 10 ns only; Totalize B by A operates for one complete cycle of Input A.	
<u>NOTE 2:</u>		Special Functions 77 and 78 require connection of a 10 MHz internal standard to Input A or B as specified in 2.6.1.3.	

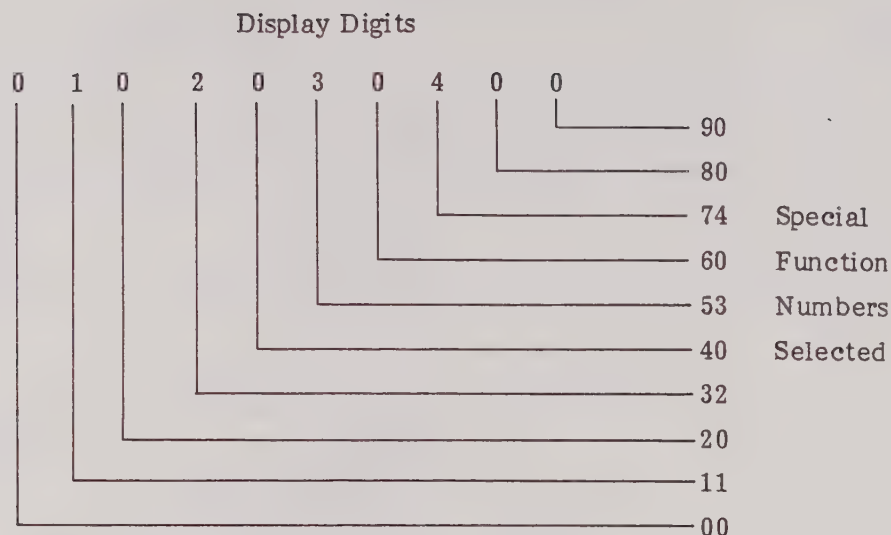


Figure 3-3. Special Function Register Display

3.5.8 Error Codes

3.5.8.1 Table 3-4 lists the error codes that may be displayed by the counter during local operation. All errors will be displayed either as "Er NN" where NN is a 2-digit code number, or simply as "Op Er."

Table 3-4. Error Codes

Displayed Codes	Error
Er 01	Signals of different frequencies used in phase measurement
Er 02	Measurement result too large or too small to display
Er 03	Overflow of internal counters
Op Er	Numerical entry error (e.g., number out-of-range or attempt to store trigger level in an auto-triggered channel)
—	Programming error
Er 50	Basic Check mode error
Er 51	Relay Check Failure Input A ———— { X1/X10 50Ω /1M AC/DC FILTER in/out COM A
Er 52	
Er 53	
Er 54	
Er 55	
Er 56	NOTE: Input B ———— { X1/X10 50Ω /1M AC/DC
Er 57	
Er 58	
	Er 51-58 only occur in the Check and Special Function 72-78 modes.

3.5.8.2 Error Code Clearance

3.5.8.2.1 Error code "Er 01" is cleared by:

- a. Performing a phase measurement on signals of equal frequency.
- b. Choosing another measurement function.

3.5.8.2.2 Error codes "Er 02" and "Er 03" are cleared by:

- a. Obtaining a measurement result that is within range.
- b. Choosing another measurement function.

3.5.8.2.3 "Op Er" is cleared by pressing the Reset key.

4.1 GPIB FUNCTIONAL CHECK

NOTE:

Programming for the 1993 conforms to IEEE-STD-488.2 (1987). Refer to that standard for details on programming methods and status byte information.

4.1.1 Introduction

4.1.1.1 The following procedure verifies the 1993's capability to accept, process, and transmit GPIB messages. Complete a satisfactory check of the counter under local control before starting this procedure (see Subsection 2.6).

4.1.1.2 Successful completion of the GPIB check indicates that the counter's GPIB interface is operating properly.

NOTE:

If any other controller or selected GPIB address combination is used, the GPIB commands in the following procedure will require change.

4.1.1.3 Connect the controller to the GPIB interface of the Wavetek 680 chassis using a standard GPIB cable. No connection should be made to Inputs A, B, or C. Set the Wavetek 680 address to 15 (7) and put the 1993 counter in slot 3 (secondary address of 03).

4.1.2 Data Output Check

4.1.2.1 Test as shown below:

Action	HP-9825/26 Code	Your Controller
Put the 1993 into the Check mode by sending the counter's listen address, followed by the device-dependent command CK?	wrt 71503, "CK?"	
Query the instrument	wrt 71503, "MEAS?"	
Prepare a store to receive a data string	DIM Z\$[50]	
Send the 1993's talk address. Store the data string in the prepared store	red 71503, Z\$	
Display the contents of the store	dsp Z\$	

4.1.2.2 Verify that the HP9825/26 display reads MEASUREMENT +0010.0000000E+06 with the cursor moved to the next line, indicating that carriage return (CR) and line feed (LF) have been accepted.

4.2 ADDRESSED MODE

4.2.1 In the Addressed mode, all of the 1993's functions (except POWER ON/OFF) can be controlled by device-dependent commands. These commands are sent over the GPIB after the counter has been addressed to listen. Completed measurement readings and counter status information are then read back over the bus after the counter is addressed to talk. If the counter is addressed to talk when its measurement buffer is empty, a status message will be sent to the controller. Measurement transfer will start at the completion of the next measurement cycle.

4.3 OUTPUT MESSAGE FORMAT (TALKER)

4.3.1 Introduction

4.3.1.1 Refer to Table 4-1. The same output format is used for transmitting measurement values as well as numbers recalled from the 1993's internal stores.

4.3.1.2 The output message consists of a string of ASCII characters for each transmitted value. Measurement units should be assumed as hertz, seconds, volts, degrees (unitless for a ratio), depending on commands previously sent to the counter.

Table 4-1. Output Message Format

Header	Query Information. "MEASUREMENT" for a Reading; "RLA" for "RLA?" Query or for whichever Recalled Data was requested
Measurement Sign	+ or -
Numeric Data	0 to 9 or .
Exponent Indicator	E
Exponent Sign	+ or -
Two-Digit Exponent	0 to 9 (multiple of 3)
Carriage Return	CR
Line Feed	LF

4.4 STATUS BYTE

4.4.1 General

4.4.1.1 All 1993 messages and status bytes are defined by IEEE-STD-488.2 (1987). Definitions of 1993 event status and status bytes registers are shown in Figure 4-1. To obtain the counter's status, first program the two masks; then read the status registers. Depending on the status condition, another query could be sent to the counter to read the status message. See Table 4-2 for 1993 status byte error codes and their meaning.

4.4.2 SRQ Enable Register (Mask)

4.4.2.1 Set bit 5 (decimal 32) to program the counter to provide SRQ notification upon event status register condition. To also provide SRQ notification upon measurement data availability, set bit 0 (decimal 1). Bit 0 is defined for the 1993 and is not part of IEEE-STD-488.2.

4.4.2.2 First, program the counter by sending the following ASCII string:

* SRE 33

4.4.2.3 Check programming correctness by sending the following query in ASCII to the counter:

* SRE?

4.4.2.4 Read the counter's output. It should be 33.

4.4.3 Event Status Enable Register (Mask)

4.4.3.1 Set all bits in the event status enable register to one. Program the counter to provide notification of all conditions of the event status register by sending the following ASCII string:

* ESE 255

4.4.3.2 Check programming correctness by sending the following query in ASCII to the counter:

* ESE?

4.4.3.3 Read the counter's output. It should be 255 or as programmed.

4.4.4 Status Byte and Event Status Registers

4.4.4.1 Determine register status by either performing a serial poll or by reading the counter output after sending the following query in ASCII:

* STB?

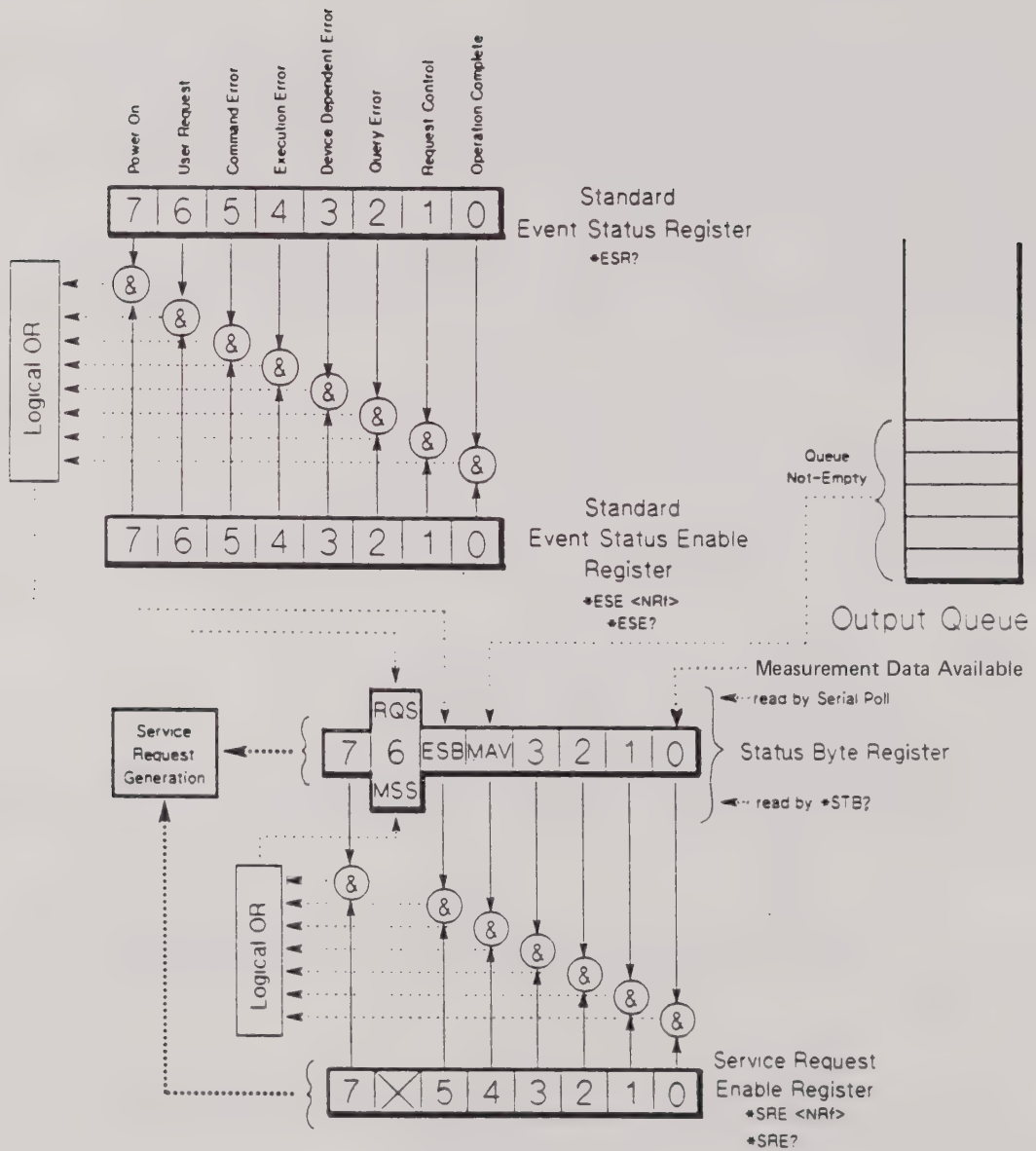


Figure 4-1. 1993 Status Data Definition

Table 4-2. Status Byte Error Codes

Error Code Number	Error Code Meaning
1	Phase measurement attempted on waveforms of differing frequency (Ratio $\neq$ 1)
2	Result out-of-range of display
3	Overflow of internal counters
4	Numerical entry error
5	Syntax (programming) error
<u>NOTE 1:</u> No measurement data is available if error codes 1 thru 3 are generated. An error message output string will be sent upon request. <u>NOTE 2:</u> A "Reading is Ready" message is not generated after a data-recall operation. <u>NOTE 3:</u> The above five error codes are cleared as follows: - Error 1 - Correct the difference in input frequencies or change the measurement mode. - Error 2 - Complete an in-range measurement. - Error 3 - Complete an in-range measurement. - Error 4 - Complete a valid numerical entry. - Error 5 - Erroneous command will be correctly executed up to the error; the rest will be handshaken, but not executed. Receipt of the next valid command clears the error.	

4.4.4.1.1 If bit 0 is set, measurement data is available. Read the counter's output for measurement data after sending the following query in ASCII:

MEAS?

Then measurement data is available by reading the counter's output.

4.4.4.1.2 If bit 5 is set, read the event status register by sending the following query in ASCII to the counter:

* ESR

Then, read the counter's output.

4.4.4.1.3 Depending on which bits are set, send one of the following queries in ASCII to the counter:

* DDE? If device-dependent error is set.

* CME? If command error is set

* EXE? If execution error is set

4.4.4.1.4 The status can be cleared by sending the following command in ASCII to the counter:

* CLS

4.4.4.1.5 To set the 1993 to original power-up conditions, send the following command in ASCII:

* RST

4.4.4.1.6 The identification of the module can be read by sending the following query in ASCII to the counter:

* IDN?

Using the 1993, the message "Racal-Dana, 680-06, 0, V1.0" should appear by reading the output.

4.4.4.1.7 By sending the following query in ASCII to the counter, a self-test is performed:

* TST?

If anything other than a 0 appears when the output is read, an error condition exists with the counter.

NOTE:

For further information refer to the Wavetek 680 Manual and IEEE-STD-488.2 (1987).

4.5 INPUT COMMANDS

4.5.1 Introduction

4.5.1.1 The 1993 responds to device-dependent commands in a "deferred" mode. This means that the counter continues to accept commands until a terminating character or message is received, then the entire string will be executed. There is no "immediate" mode in which commands are obeyed as they are received.

4.5.2 Device-Dependent Commands

4.5.2.1 When the counter is addressed to listen, it can be controlled by device-dependent commands. These commands are listed below, and tabulated in Tables 4-3 to 4-12.

- a. Table 4-3 - Instrument Preset Code
- b. Table 4-4 - Numerical Input Format
- c. Table 4-5 - Measurement Function Codes
- d. Table 4-6 - Numerical Input Ranges
- e. Table 4-7 - Resolution Selection
- f. Table 4-8 - Input Control Codes
- g. Table 4-9 - Measurement Control Codes
- h. Table 4-10 - Store and Recall Codes
- i. Table 4-11 - Special Function Codes
- j. Table 4-12 - Alphabetic List of Command Codes

4.5.2.2 Device-dependent commands are executed sequentially beginning with the first one sent and ending with the last.

4.5.2.3 If more than one command is to be sent, delimiters are required. Semicolons must be included in the command strings for compliance with IEEE-STD-488.2.

4.5.2.4 Each command string must be followed by an end-of-string terminating group. See the Wavetek 680 Manual for the valid terminator groups.

4.5.2.5 Table 4-3 provides the instrument preset code for the 1993.

Table 4-3. Instrument Preset Code

Function	Code
Sets counter functions and settings to home state	IP

4.5.2.6 Some of the device-dependent commands in the following tables require additional numerical input data. Such numerical input follows its command and is indicated by a plus sign (+) in the tabulations. Also, home-states are underlined. Refer to Table 4-4 as required for numerical input format.

Table 4-4. Numerical Input Format

Byte Number	Interpretation	Permitted ASCII Characters
1	Sign of mantissa	+ or -
2	Most significant digit	0 to 9 or .
3	Digit	
4		
5		
6		
7		
8		
9		
10		
11	Least significant digit	
12	Exponent indicator	E or e
13	Exponent sign/space	+ or - or space
14	More significant digit	0 to 9
15	Less significant digit	0 to 9

NOTE 1:

Spaces, nulls, or zeros occurring before byte 1 are ignored by the counter.

NOTE 2:

Byte 1 may be omitted and a positive mantissa assumed.

NOTE 3:

Bytes 2 to 11 may have up to 9 digits and a decimal point. The decimal point, however, is not essential. After entry of 9 digits (without a decimal point), additional digits are ignored and a GPIB programming error is generated. Excess digits that are truncated will still increase the power-of-ten stored. Also, if fewer than 9 digits are needed, unused bytes may be omitted.

NOTE 4:

Spaces or nulls entered between bytes 11 and 12 are ignored by the counter.

NOTE 5:

Bytes 12 to 15 (exponent group) may be omitted. Also, byte 13 may be omitted or transmitted as a space (a positive exponent should be assumed in either instance).

NOTE 6:

Byte 15 may be omitted for a single-digit exponent.

Table 4-4. Numerical Input Format (Continued)

NOTE 7:

Numbers may be terminated by one of the same terminators used for output messages, or by another device-dependent message.

NOTE 8:

Units are implied; volts for trigger levels, seconds for gate/delay times.

4.5.2.7 Table 4-5 presents the measurement function codes for the 1993.

Table 4-5. Measurement Function Codes

Function	Code
Frequency A	FA
Frequency B	FB
Frequency C	FC
Period A	PA
Time Interval A→B	TI
Totalize A by B	TA
Ratio A/B	RA
Ratio C/B	RC
Rise Time A	RT
Fall Time A	FT
Positive Pulse Width A	PW
Negative Pulse Width A	NW
Phase A rel B	PH
Check	CK

NOTE 1:

Option 41 must be installed in the 1993 for FC and RC to be accepted as valid commands.

NOTE 2:

Different commands placed on the same input line must be separated by a ";".

Table 4-5. Measurement Function Codes (Continued)

NOTE 3:

For any measurement mode, query the counter by sending the query "MEAS?" before reading the output.

For example, a frequency measurement would be as follows:

```
0: dim A$ [99]
1: wrt 71503, "FA"
2: wait 1000
3: wrt 71503, "MEAS?"
4: red 71503, A$
5: prt A$
```

4.5.2.8 Table 4-6 provides the various numerical input ranges for the 1993.

Table 4-6. Numerical Input Ranges

Function	Command Code	Numerical Limits	
		Low	High
Resolution	SRS	3	10
Trigger Level (X1)	SLA, SLB	-5.1	+5.1
Trigger Level (X10)	SLA, SLB	-51	+51
Math Constant	SMX, SMY, SMZ	1×10^{-9}	1×10^{10}
		0	
Delay/Gate Time	SDT/SGT	-1×10^{10} 200 μ s	-1×10^{-9} 99.999 s

NOTE 1:

Entered numbers will be rounded up before storage as follows:

- Trigger level X1 to next multiple of 20 mV
- Trigger level X10 to next multiple of 200 mV
- Delay/gate time to next multiple of 25.6 μ s

NOTE 2:

Resolution entries are rounded down to the next integer. Refer to Table 3-2 for related gate times and GPIB resolution numbers.

NOTE 3:

Math constant Z can be set to zero. However, an error message will result if the Math function is enabled with this value set.

4.5.2.9 Table 4-7 provides the 1993 resolution selection.

Table 4-7. Resolution Selection

Resolution Number	Number of Selected, Digits in Frequency, Period, Ratio, and Check	Gate Time
10	9 + Overflow	10 s
9	9	1 s
8	8	100 ms
7	7	10 ms
6	6	1 ms
5	5	1 ms
4	4	1 ms
3	3	1 ms

NOTE:

Refer also to Table 3-2 as required. It shows the relationship of gate time and display resolution in the 1993.

4.5.2.10 The following tables complete the necessary commands for the 1993:

Table 4-8. Input Control Codes

Function	Code
<u>F</u> ILTER <u>D</u> isable/ <u>E</u> nable	<u>A</u> FD/ <u>A</u> FE
<u>C</u> OM <u>A</u> <u>D</u> isable/ <u>E</u> nable	<u>B</u> CS/ <u>B</u> CC
<u>D</u> C/ <u>A</u> C <u>C</u> oupling <u>A</u>	<u>A</u> DC/ <u>A</u> AC
<u>D</u> C/ <u>A</u> C <u>C</u> oupling <u>B</u>	<u>B</u> DC/ <u>B</u> AC
<u>1</u> M /50 Ω impedance <u>A</u>	<u>A</u> HI/ <u>A</u> LI
<u>1</u> M /50 Ω impedance <u>B</u>	<u>B</u> HI/ <u>B</u> LI
<u>S</u> lope <u>A</u> <u>+</u> ve/ <u>-</u> ve	<u>A</u> PS/ <u>A</u> NS
<u>S</u> lope <u>B</u> <u>+</u> ve/ <u>-</u> ve	<u>B</u> PS/ <u>B</u> NS
<u>X</u> 10 attenuator <u>A</u> <u>D</u> isable/ <u>E</u> nable	<u>A</u> AD/ <u>A</u> AE
<u>X</u> 10 attenuator <u>B</u> <u>D</u> isable/ <u>E</u> nable	<u>B</u> AD/ <u>B</u> AE
<u>M</u> anual/ <u>A</u> UTO- <u>T</u> RIG <u>A</u>	<u>A</u> MN/ <u>A</u> AU
<u>M</u> anual/ <u>A</u> UTO- <u>T</u> RIG <u>B</u>	<u>B</u> MN/ <u>B</u> AU

Table 4-9. Measurement Control Codes

Function	Code
<u>Continuous measurement mode selection</u>	<u>T0</u> (See NOTE 1)
<u>Single (One-Shot) measurement mode selection</u>	<u>T1</u> (See NOTE 2)
<u>Start Totalize or trigger a measurement (T1 mode)</u>	<u>T2</u> (See NOTE 3)
<u>Stop Totalize</u>	<u>T3</u> (See NOTE 3)
<u>Read current value while measurement is in progress (i.e., next reading on the fly)</u>	<u>RF</u> (See NOTE 4)
<u>Math function Disable/Enable</u>	<u>MD/ME</u>
<u>Delay Disable/Enable</u>	<u>DD/DE</u>
<u>100 AVG Disable/Enable</u>	<u>NA/AE</u>
<u>Reset measurement</u>	<u>RE</u>

NOTE 1:

In continuous measurement mode, the output buffer is updated at the end of each gate period. If the buffer is being read out via the bus when the gate period ends, updating is delayed until reading is complete.

NOTE 2:

In single-measurement mode, the output buffer is cleared every time a T1 command is received. The measurement completed must be read, therefore, before the next measurement cycle is triggered.

NOTE 3:

In making totalize measurements, T2 and T3 commands are used with the TA command and Special Function 61. In this mode, the readings executed in successive totalize periods are cumulative; (the RE command being used to reset the count to zero when required).

NOTE 4:

The RF command must be sent each time a reading is required. The reading is obtained when the output buffer is read.

Table 4-10. Store and Recall Codes

Function	Code
Recall unit type	RUT?
Store/Recall display resolution (Defaults to 8)	+SRS/RRS? (See NOTE 2)
Store/Recall trigger level A (Defaults to 0 V)	+SLA/RLA? (See NOTE 1)
Store/Recall trigger level B (Defaults to 0 V)	+SLB/RLB? (See NOTE 1)
Store/Recall math constant X (Defaults to 0)	+SMX/RMX? (See NOTE 2)
Store/Recall math constant Y (Defaults to 1)	+SMY/RMY? (See NOTE 2)
Store/Recall math constant Z (Defaults to 1)	+SMZ/RMZ? (See NOTE 2)
Store/Recall arming delay time (Defaults to 200 μ s)	+SDT/RDT? (See NOTE 2)
Store/Recall gate time (Defaults to 100 ms)	+SGT/RGT? (See NOTE 2)
Recall master software issue	RMS?
Recall GPIB software issue	RGS?

NOTE 1:

The manual trigger level is automatically scaled by a factor of 10 when the X10 attenuator setting is chosen. Correct input attenuation must be selected before storing or recalling the trigger level.

NOTE 2:

Store functions with a + sign require a numeric input. Program the 3-character command, followed by a required blank space, followed by the number.

Table 4-11. Special Function Codes

Function	Code
Special functions <u>Disabled/Enabled</u> Store special function nn	<u>SFD/SFE</u> <u>SSF nn</u>
Recall special function (Defaults to all SFs off)	RSF?
<u>NOTE 1:</u> The list of special function numbers (SSFs) is provided in Table 3-13.	
<u>NOTE 2:</u> Storing a special function when special functions are enabled immediately enables that special function.	
<u>NOTE 3:</u> A "Reading is Ready" status is not generated by data recalled from stores.	

Table 4-12. Alphabetic List of Command Codes

Code	Command	Code	Command
AAC	A Channel, AC coupling	NA	100 Average disabled
AAD	A Channel, X10 attenuator disabled	NW	Negative pulse width A
AAE	A Channel, X10 attenuator enabled	PA	Period A
AAU	A Channel auto-trigger	PH	Phase A relative to B
ADC	A Channel, DC coupling	PW	Positive pulse width A
AE	100 Average enabled	RA	Ratio A/B
AFD	A Channel filter disabled	RC	Ratio C/B
AFE	A Channel filter enabled	RDT?	Recall arming delay time
AHI	A Channel, 1 Mohm	RE	Reset measurement
ALI	A Channel, 50 ohms	RF	Read total so far
AMN	A Channel manual trigger	RGS?	Recall software issue number
ANS	A Channel, -ve slope	RGT?	Recall gate time
APS	A Channel, +ve slope	RLA?	Recall trigger level A
BAC	B Channel, AC coupling	RLB?	Recall trigger level B
BAD	B Channel, X10 attenuator disabled	RMS?	Recall master software issue number
BAE	B Channel, X10 attenuator enabled	RMX?	Recall math constant X
BAU	B Channel auto-trigger	RMY?	Recall math constant Y
BCC	A and B Channels common	RMZ?	Recall math constant Z
BCS	A and B Channels separate	RRS?	Recall display resolution
BDC	B Channel, DC coupling	RSF?	Recall special function
BHI	B Channel, 1 Mohm	RT	Rise time A
BLI	B Channel, 50 ohms	RUT?	Recall unit type
BMN	B Channel manual trigger	SSF	Special function number
BNS	B Channel, -ve slope	SDT	Store arming delay time
BPS	B Channel, +ve slope	SFD	Special function disabled
CK	Check	SFE	Special function enabled
DD	Delay disabled	SGT	Store gate time
DE	Delay enabled	SLA	Store trigger level A
FA	Frequency A	SLB	Store trigger level B
FB	Frequency B	SMX	Store math constant X
FC	Frequency C	SMY	Store math constant Y
FT	Fall time A	SMZ	Store math constant Z
IP	Instrument Preset	SRS	Store display resolution
MD	Math function disabled	Tn	Measurement mode or start/stop reading
ME	Math function enabled	TA	Total A by B
		TI	Time Interval

5.1 INTRODUCTION

5.1.1 This section describes the general theory of operation for the 1993.

5.1.2 The theory of operation provided is based on the simplified overall block diagram shown in Figure 5.1. Key circuit blocks of the 1993 are described and supported in this section using simplified block and schematic diagrams. These diagrams supplement the complete schematics found in Section 7 of this manual. As much as possible, the simplified schematic and block diagrams provided here use the same reference designators found in the complete schematics. This should facilitate cross-referencing between this section of the manual and the schematics.

5.1.3 Integrated circuits (ICs) in the following circuit descriptions are designated by circuit references provided on the supporting simplified block and schematic diagrams. The IC designations employed in the following key circuit descriptions follow those found in supplied schematics.

When an IC package contains more than one circuit, suffix letters are used to distinguish them (e.g., IC1a). Finally, when it is necessary to identify a specific pin in an IC, the reference designator, with a suffix letter if necessary, is followed by a hyphen and then the required pin number (e.g., IC1a-1).

5.2 FUNCTIONAL BLOCKS

5.2.1 The 1993 contains the following seven main functional blocks:

- a. Channel A/B block (see Subsection 5.3.1)
- b. Channel C block (see Subsection 5.3.2)
- c. Measurement block (see Subsection 5.3.3)
- d. Microprocessor block (see Subsection 5.3.4)
- e. IRQ block (see Subsection 5.3.5)
- f. DC Filtering/Regulating block (see Subsection 5.3.6)
- g. 680 Interface (see Subsection 5.3.7)

5.2.2 The functional relationship between the blocks of the 1993 is illustrated in Figure 5.1. The measurement block is internally configured by the microprocessor according to the instructions entered via the the 680 keyboard or over the 680 interface bus. The signal to be measured and the signal from the frequency standard are fed to the measurement block. The measured result is passed to the microprocessor. If mathematical manipulation of the result is required, this is performed by the microprocessor before the final output is passed to the system or the 680 display.

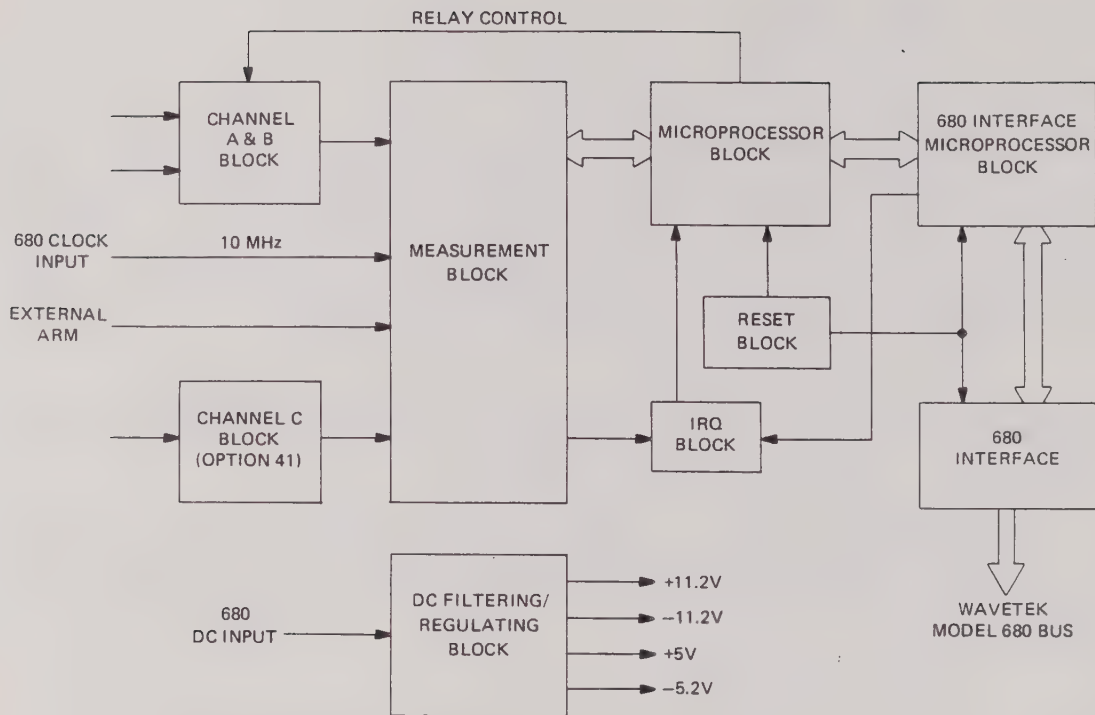


Figure 5.1 - Simplified 1993 Block Diagram

5.3 THEORY OF OPERATION BY BLOCK

5.3.1 Channel A/B Block

5.3.1.1 Functional Description

5.3.1.1.1 Channel A/B block processes the signals applied at the respective A/B inputs to produce differential pairs of signals which are fed to the measurement block. A block diagram is shown in Figure 5.2.

5.3.1.1.2 Each channel includes relay-controlled circuits which allow selection of 50 Ω /1M Ω input impedance, AC/DC coupling, and X1/X10 attenuation. The COM(mon) A configuration (Channel B signal disconnected and Channel A signal connected to both amplifiers in parallel) can be selected.

5.3.1.1.3 The channel amplifiers feature separate high frequency and low frequency paths. The crossover frequency is nominally 5 kHz. Signal filtering can be introduced, in Channel A only, by disconnecting the high-frequency amplifier path and increasing the bandwidth of the low frequency path to 50 kHz nominal. The signals from the high and low frequency paths are combined and drive a Schmitt trigger output stage.

5.3.1.1.4 The trigger levels for the two channels are derived independently in the digital-to-analog converter (DAC) using data supplied from the microprocessor.

5.3.1.1.5 Control signals for the system relays are supplied from the microprocessor.

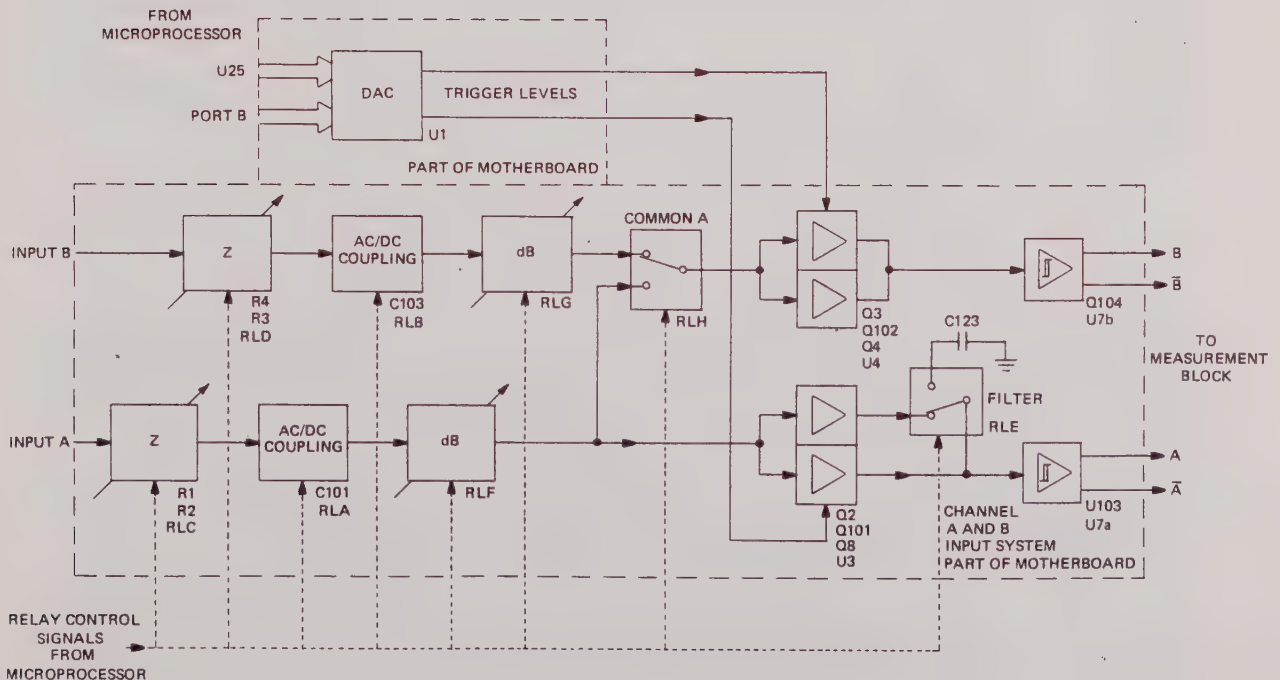


Figure 5.2 - Channel A/B Block Diagram

5.3.1.2 Circuit Description

5.3.1.2.1 Refer to the schematic shown on page 7-10. When relay RLC is energized, the input impedance seen at SK5 (INPUT A) is 50 Ω , given by resistors R1 and R2 in parallel.

5.3.1.2.2 When energized, RLA gives DC coupling of the input signal. With RLA deenergized, the signal is AC coupled via C101. R101 limits the current surge which occurs if DC coupling is selected while C101 is in the charged state.

5.3.1.2.3 The X1/X10 attenuator is formed by R8, R7, Z2 and RLF. With RLF deenergized, the attenuator has a series element, R8, and a shunt element formed by R7 and Z2 in parallel. The attenuation is 20 dB (nominal). With RLF energized R8 is short-circuited, giving 0 dB attenuation.

5.3.1.2.4 The attenuator output is fed to the high-frequency channel buffer, Q2 and Q101, via R110 and C113. The gate of Q2 is protected against excessive negative voltage swings by CR3. The gain from the attenuator output to the emitter of Q101 is approximately 0.94.

5.3.1.2.5 The buffer of the low frequency channel, U3 and Q8, receives its input from the potential divider Z2. The gain from Z2 pin 1 to the emitter of Q8 is approximately 0.94. Any offset in the system can be nulled by adjusting R192.

5.3.1.2.6 When RLE is deenergized (Channel A filter not selected), the signals from the two buffers are combined at the base of Q103 by the network C124 and R137. These components act as a low-pass filter to the output of the low frequency buffer, and as a high-pass filter to the output of the high frequency buffer. The crossover frequency is 5 kHz.

5.3.1.2.7 The signal at 103 emitter is fed to the Schmitt trigger U7a via the diode bridge formed by CR10, CR12, CR11 and CR13. This protects the input of U7a by limiting the signal swing to approximately $\pm 1V$.

5.3.1.2.8 The differential output of U7 forms the input to the measuring block. The hysteresis of U7, and therefore the channel sensitivity, can be set by adjusting R16.

5.3.1.2.9 The trigger level is set by the DAC, U1, shown on page 7-11 and is fed to U3-2 via R134 and one section of Z5. Feedback, taken from the emitter of Q103 to U3-2 via Z5 pins 5 and 3, makes Z5 pin 3 a virtual ground point, and the gain from the ???/R134 junction to the emitter of Q103 is -0.94. A 1 VDC level at the Channel A input and a 1V trigger level, therefore, combine to give 0V at Q103's emitter. Thus, the selected trigger point on the input signal is always brought to 0V at Q103's emitter.

5.3.1.2.10 When Channel A's low-pass filter is selected, RLE is energized. This opens the high-frequency channel circuitry and connects C123 across the low frequency channel. The low-frequency channel bandwidth is then nominally 50 kHz.

5.3.1.2.11 The circuit of Channel B is similar to that of Channel A, but is not provided with a low-pass filter. Energizing RLH connects the signal applied at the Channel A input to both channel amplifiers.

5.3.1.2.12 The relays are controlled by the microprocessor. The voltage levels on the control lines are latched in U16 as shown on page 7-11.

5.3.2 CHANNEL C (OPTION 41) BLOCK

5.3.2.1 Functional Description

5.3.2.1.1 Refer to the block diagram given in Figure 5.3. Channel C processes the signal applied at the Channel C input and feeds it to the measurement block.

5.3.2.1.2 Channel C's input is protected by a fuse, mounted in the input connector, and by a signal-limiting circuit. Next is an automatic level control circuit which reduces the range of the signal level applied to the amplifier.

5.3.2.1.3 After amplification, the signal is prescaled by 64 before being passed via a buffer and a signal gate to the measurement block.

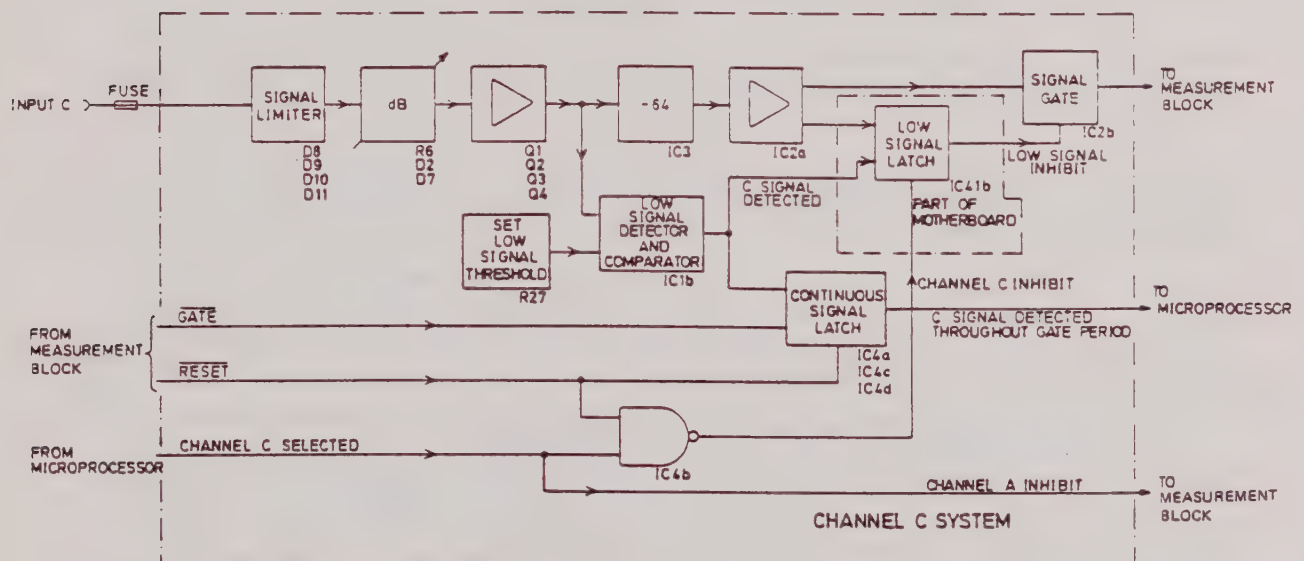


Figure 5.3 - Channel C Block Diagram

5.3.2.1.4 The amplitude of the signal at the amplifier output is monitored by a detector and comparator. The comparator output controls the low-signal latch. If the detector output is below the threshold, the latch is set and the channel output is inhibited by the signal gate. When the detector output goes above the threshold, the low-signal latch is armed and opens the signal gate on the next signal edge from the prescaler. This enables the instrument to make measurements on signal bursts.

5.3.2.1.5 The detector output is also applied to the continuous signal latch. This latch is reset at the beginning of each gate period and is set if the detector output falls below the threshold level. The microprocessor samples the latch output throughout the gate period. If the measured signal falls below the threshold level during this period, the measured result is set to zero.

5.3.2.1.6 If Channel C is not selected, the low-signal latch is held in reset by a control signal from the microprocessor and the output to the measurement block is inhibited. The same control signal is used to enable Channel A so that the two channels cannot be enabled at the same time.

5.3.2.2 Circuit Description

5.3.2.2.1 Refer to the schematic shown on page 7-36. The signal to be measured is connected via SK13 (INPUT C). The circuit is protected by a fuse which is mounted within SK13. The signal amplitude is limited by the diode clamp comprised of D8, D9, D10, and D11.

5.3.2.2.2 A degree of automatic gain control is achieved by means of an attenuator, formed by R6 and the impedance of the PIN diodes D2 and D7. The peak-to-peak detector D1, D3, R7, and C48 produces a negative voltage proportional to the signal amplitude. A direct current proportional to this voltage flows through the PIN diodes via L1. The impedance of the diodes decreases if the current increases so that changes in signal amplitude are offset by changes in attenuation.

5.3.2.2.3 The signal passes through four amplifier stages incorporating Q1, Q2, Q3, and Q4. The amplified signal is fed to the counter IC3 via the shaping circuit formed by R37, C46, and R36.

5.3.2.2.4 The signal frequency is prescaled by 64 in IC3 and buffered in IC2a. Provided that Channel C is selected and the amplitude of the signal is adequate, the output at IC2a-2 passes to the measurement block via the gate IC2b and SK7 pin 5.

5.3.2.2.5 The signal at the output of Q4 is fed to the low-signal detector D5 and C23. The comparator IC1b compares the detector output with a threshold voltage set by R27. The comparator output is at logic 1 if the detector output is below the threshold (Channel C's signal amplitude too low for accurate counting).

5.3.2.2.6 The logic level at the comparator output is inverted in IC1-A and is fed via SK7 pin 14 to the D input (pin 10) of the low-signal latch IC41b shown on page 7-11. IC41b is clocked by the output of IC2-A via SK7 pin 8. If the signal from Q4 is below the threshold, IC41b-14 goes to logic 1. This level is fed back via SK7 pin 7 to disable the gate IC2-B and inhibit the output to the measurement block.

5.3.2.2.7 The GATE signal enters the system at SK7 pin 17 and is inverted in IC1-C. The resulting signal and the output of the comparator IC1-B are fed to IC4-A. If both inputs are at a logic 1, indicating that the Channel C signal level is too low while the gate is open, the continuous signal latch IC4-C and IC4-D is set. The latch output is fed to the microprocessor via SK7 pin 11 and prevents the result of any measurement made during that gate period from being displayed.

5.3.2.2.8 The U signal at SK7 pin 16 is at a logic 1 when Channel C is selected. A buffered version of this signal is fed to SK7 pin 1 via IC2-C and disables Channel A at IC41a shown on page 7-11. When Channel C is not selected, SK7 pin 16 is at logic 0. This level is inverted and buffered in IC4-B and IC1-D, and is then fed to IC41b via SK7 pin 13. IC41b is held in reset, inhibiting the Channel C signal at IC2-B via SK7 pin 7.

5.3.3 Measurement Block

5.3.3.1 Functional Description

5.3.3.1.1 The measurement circuits of the instrument are provided by three custom-built integrated circuits. These are the two Multiple Counter and Control (MCC) circuits, MCC1 and MCC2, and the Timing Error Correction (TEC) circuit. A block diagram is shown in Figure 5.4.

5.3.3.1.2 The circuits within MCC1 and MCC2 are configured by the microprocessor according to the measurement function selected. The recipromatic counting technique is used. With this technique the measured signal, not the counter clock pulses, controls the start and stop of the measurement period (gate time) as shown in Figure 5.5. The gate time, therefore, extends over an integral number of cycles of the measured waveform. The gate time is measured by counting the clock pulses which occur while the gate is open. This leads to timing errors at both ends of the gate time, as shown. The TEC circuit enhances the measurement accuracy by compensating for these errors.

5.3.3.1.3 For all measurement functions except FREQ A and PERIOD A, the signals to be measured are fed directly to MCC2. For FREQ A and PERIOD A, the Channel A signal is scaled by two and fed to the C input of MCC2. When FREQ C is selected, the prescaler is disabled by the CHANNEL A INHIBIT signal from the Channel C block.

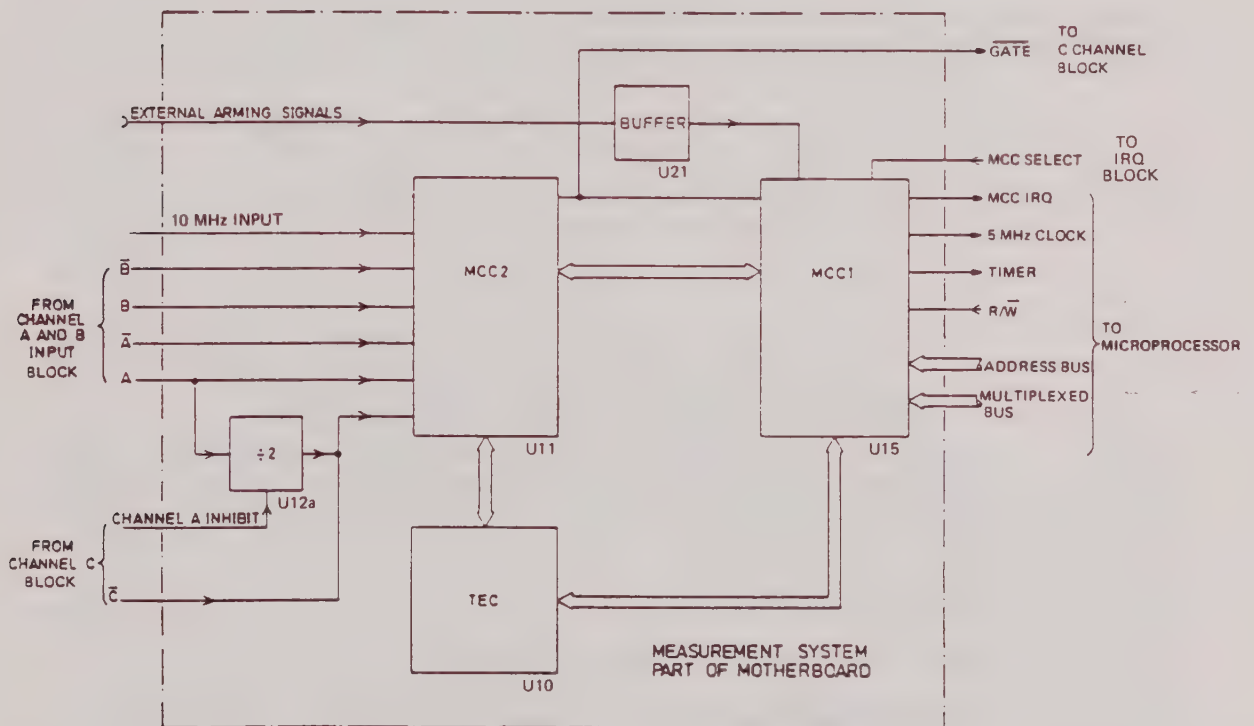


Figure 5.4 - Measurement - Block Diagram

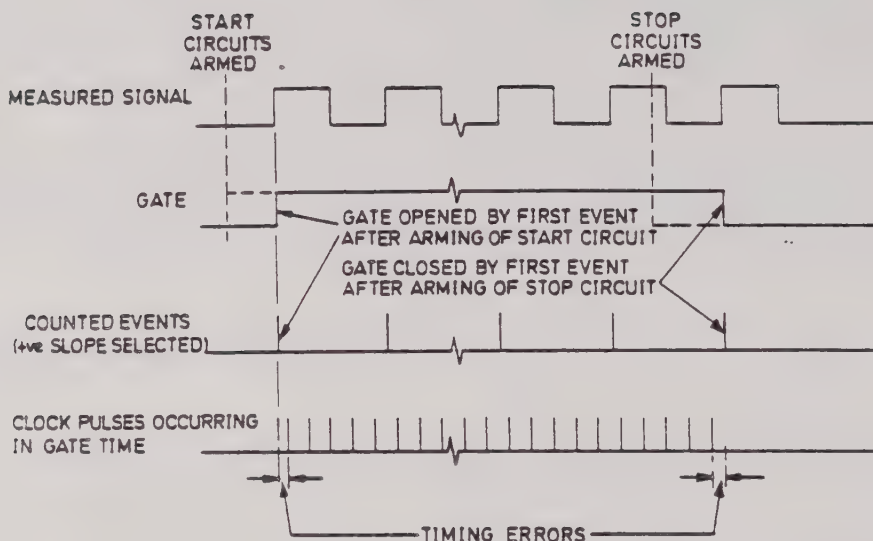


Figure 5.5 - Basic Recipromatic Counting Technique

5.3.3.1.4 At the end of each measurement period, MCC1 generates an interrupt request for the microprocessor. The registers within MCC1 are addressed using the address bus and the MCC SELECT line. The measured value is transferred to the microprocessor via the multiplexed bus.

5.3.3.2 Circuit Description

5.3.3.2.1 Refer to the schematic shown on page 7-11.

5.3.3.2.2 Measured Signal Input

5.3.3.2.2.1 For all measurement functions other than FREQ A and PERIOD A, the differential outputs from Channel A and Channel B are applied to the measuring circuit at U11-15, 16, 17 and 18. For the FREQ A and PERIOD A functions, the A signal frequency is divided by two in U12a and fed to U11-19.

5.3.3.2.2.2 For the FREQ C and RATIO C/B functions, the C signal is fed to U11-19. For these functions U12a-5 is held at logic 1 by the PST1 control line (CHANNEL A INHIBIT) from the Channel C block. As a result, U12a is held in set and the A signal is inhibited from reaching U11-19.

5.3.3.2.3 Reference Frequency

5.3.3.2.3.1 The reference signal is applied to U11-2.

5.3.3.2.3.2 A 10 MHz reference signal, from Model 680, is present at U11-36. This signal is applied to the TEC, U10 at pin 6, and, after inversion in U19e, to U15-24.

5.3.3.2.4 Microprocessor Clock and Timer

5.3.3.2.4.1 A 5 MHz clock signal for the microprocessor (and the 680 interface microprocessor if fitted) is taken from U15-2. A 39.0625 kHz clock signal for the microprocessor timer is taken from U15-4.

5.3.3.2.5 Channel C Gate and Reset

5.3.3.2.5.1 A GATE signal (logic 0 during the measurement period) and a RESET signal (negative-going pulse at the end of each measurement period) are taken from U11-27 and U15-40 and fed to the Channel C block via PL1-17 and 15.

5.3.3.2.6 External Arming Input

5.3.3.2.6.1 Signals connected to the EXT ARM INPUT socket on the rear of the instrument are fed to U15-27 via J5 pin 1 and the buffer stage U21.

5.3.3.2.7 Control Signals

5.3.3.2.7.1 The logic levels on lines Q0 to Q4, between U15 and U11 are shown in Table 5.1. These levels are stable if the following conditions exist:

- a. No signals are applied to any of the channel inputs
- b. Auto-trigger is disabled on Channels A and B

Table 5.1 - Control Logic Levels by Function

Measurement	Control Line				
<u>Function:</u>	QQ	Q1	Q2	Q3	Q4
FREQ A	1	1	0	1	0
PERIOD A	1	1	0	1	0
FREQ B	1	0	0	1	0
PERIOD B	1	0	0	1	0
FREQ C	1	1	0	1	0
T.I. A→B	0	0	1	1	0
T.I. B→A	0	0	0	1	0
TOTAL A by B	1	0	0	1	1
TOTAL B by A	1	0	1	1	1
RATIO C/B	1	1	0	1	1
RATIO A/B	1	0	1	1	1
Special Function 72	1	1	1	0	1
Special Function 73	1	1	1	0	0
Special Function 74	1	1	1	0	1
Special Function 75	1	1	1	0	0

NOTES:

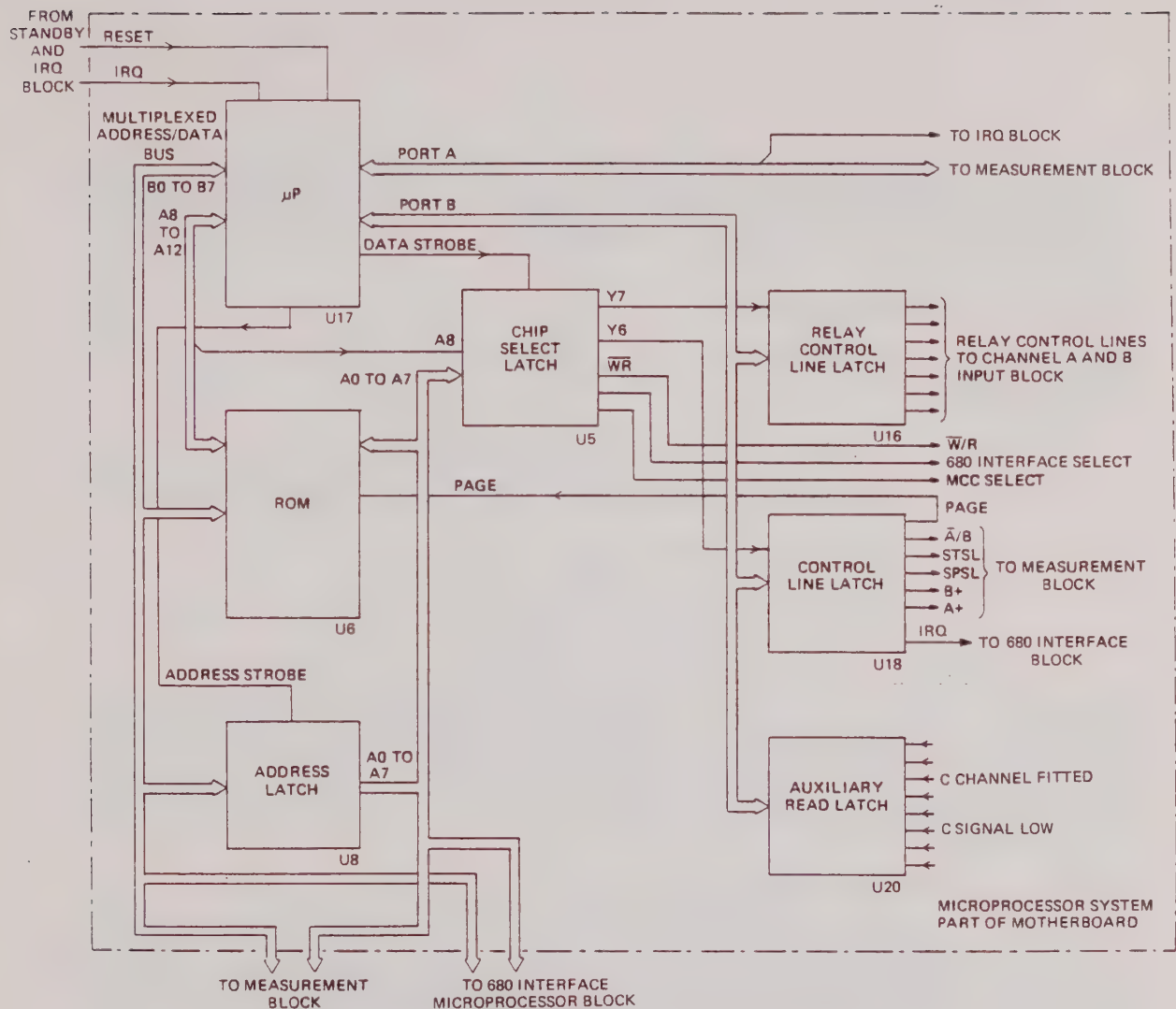
- a. The FREQ B, PERIOD B, TOTAL B by A, and T.I. B → A functions are obtained using Special Function 21.
- b. Special Functions 72 to 75 can only be used when CHECK is selected.

5.3.4 Microprocessor Block

5.3.4.1 Functional Description

5.3.4.1.1 A simplified diagram of the microprocessor block is given in Figure 5.6. The microprocessor used has a 5-bit bus for the high-order address bits and an 8-bit multiplexed bus which is used for the low-order address bits and for data. The low-order address bits are strobed into the address latch, which holds them on an 8-bit address bus, to free the multiplexed bus for data.

5.3.4.1.2 Two latches, fed from port B of the microprocessor, are used to maintain voltage levels on the instrument control lines. A third latch is used to read the status of the instrument flags via port B. The latches and registers for the connection of the multiplexed bus to the measurement system are in the measurement block, and are controlled by the MCC SELECT signal. The display data latches are in the display block, and are controlled by strobe and chip select signals obtained from port A.



5.3.4.2 Circuit Description

5.3.4.2.2 The microprocessor bus for the high-order address bits is designated A8 to A12. The multiplexed bus, used for the low-order address bits and for data is designated B0 to B7. The microprocessor also has two input/output ports PA0 to PA7 and PB0 to PB7.

5.3.4.2.3.1 The microprocessor puts U17-6 (ADDRESS STROBE) at logic 1 and (DATA STROBE) at logic 0. This enables the address latch U8 (U8-11 at logic 1), disables ROM U6 (U6-20 at logic 1), and disables the address decoder U5 (U5-6) at logic 0).

5.3.4.2.3.2 This address is put onto lines B0 to B7 and A8 to A12. When the lines have settled, the ADDRESS STROBE line is taken to logic 0. The low-order bits of the address are latched into U8 and are held on address lines A0 to A7. Lines D0 to D7 are now free for use as a data bus.

5.3.4.2.4 Address Decoding

5.3.4.2.4.1 The levels on address lines A6 to A12 are decoded in U5 to provide the following outputs:

- a. MCC SEL, the chip-select signal for U15
- b. 680 Interface, the chip-select for the 680 Interface address decoder
- c. WR, the write control signal for H2
- d. Y6, the chip select signal for output latch U18
- e. Y7, the chip select signal for output latch U16

5.3.4.2.4.2 These outputs are only available when IC21 is enabled by a logic 1 at U5-6 and a logic 0 at U5-4,5. The level at U5-6 is set by the DATA STROBE output at U17-4, which is at logic 1 when the multiplexed bus is available for data transfer. All outputs from U5 are decoded from addresses with lines A9 to A12 at logic 0 when U5-4, 5 are held at logic 0 by the output from U14a, b, and d.

5.3.4.2.5 Input and Output Latches

5.3.4.2.5.1 The logic levels required on the instrument control lines and on the PAGE line (most significant bit of RAM address) are set into the output latches U16 and U18 from data port B of the microprocessor. The latch strobe signals are decoded in U5. Data may be read by the microprocessor from the input latch U20. The latch strobe signal is provided via data port A of the microprocessor.

5.3.5 IRQ Block

5.3.5.1 Functional Description

5.3.5.1.1 This block generates reset signals for the microprocessor and GPIB interface, and the standby switching signal for the power supply system. It also combines the IRQ signals from the GPIB interface, the measurement block, and the keyboard block for connection to the microprocessor. A block diagram is given in Figure 5.7.

5.3.5.1.2 Reset signals for the microprocessor and the 680 interface are generated whenever +5V is applied to or removed from the instrument.

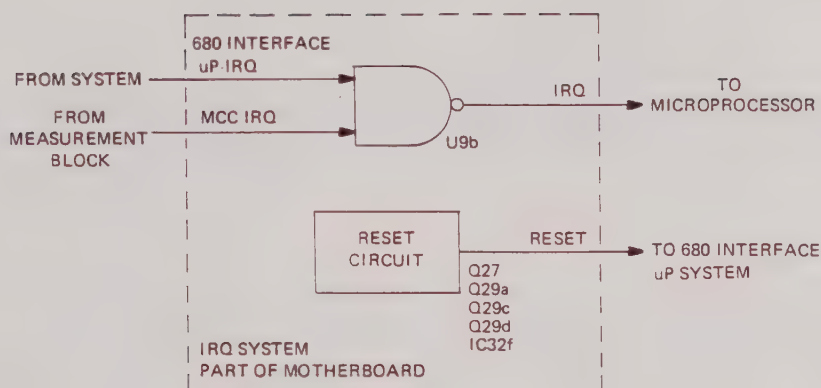


Figure 5.7 - IRQ Block Diagram

5.3.5.2 Circuit Description

5.3.5.2.1 The schematic is shown on page 7-11.

5.3.5.2.2 Reset Circuit

5.3.5.2.2.1 The RESET signal is generated in the circuit containing Q27, Q29a, d, and e, and C125. When the instrument is switched on, the input to IC32f is held low until C125 charges through R215, Q29a, and R216. The output at IC32f-12 goes to logic 1 when power is applied, but drops to logic 0 after approximately 500 ms. This output is inverted by IC32e to provide the microprocessor reset and by Q29c to provide the GPIB reset.

5.3.5.2.2.2 If there is a reduction in the +5V STANDBY supply, due to the instrument being switched off or to power failure, the potential across R217 falls. The potential at Q27 emitter is maintained by the charge in C125, so Q27 conducts. The current in R218 makes the base of Q29d positive, so the transistor conducts and holds the base of Q27 low until C125 is completely discharged. This ensures that a good reset action is obtained, even if the power is quickly restored.

5.3.5.2.3 The IRQ Circuits

5.3.5.2.3.1 Interrupts from the measurement system (MCC IRQ) and the 680 interface (IFCSYSIRQ) are connected to U9B-5 and U9B-4.

5.3.5.2.3.2 If any of these interrupts occur, U9B-8 will go to logic 1 and the interrupt signal passes via U19-12 to U17-2.

5.3.6 DC Filter Block

5.3.6.1 Functional Description

5.3.6.1.1 The +5V and -5.2V is taken from the 680 Model and the $\pm 15V$ is regulated to $\pm 11.2V$ by U25 and U24. All voltages are filtered by C18-31.

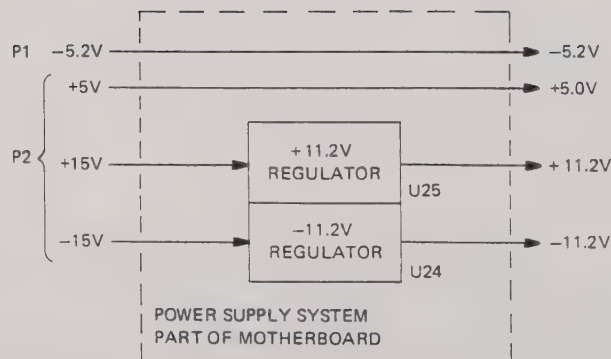


Figure 5.8 - Power-Supply-Block Diagram

5.3.6.2 Circuit Description

5.3.6.2.1 Regulated supplies at $\pm 11.2V$ are provided by the regulators U25 and U24. The common terminals of these regulators are held at approximately $-0.7V$ and $+0.7V$ by diodes D19 and D20.

5.3.6.2.2 Regulated supplies at $+5V$ are provided by Model 680 at P2 and P1. The $+5V$ is separated into 2 areas:

- 1) the 680 Interface and
- 2) the measurement

5.3.6.2.3 A regulated supply at $-5.2V$ is provided by Model 680 at P2. The reason is to keep the front end and measurement separate from the 680 interface data exchange.

5.3.7 Model 680 Interface

5.3.7.1 Introduction

5.3.7.1.1 The 680 interface is a self-contained, microprocessor-controlled system. It handles the transfer of data between its internal memory and the 680 BUS without involving the main instrument's microprocessor. Data transfer is made one byte at a time, each transfer being controlled by the SUB-VME handshake protocol. Refer to the schematic on page 7-18.

5.3.7.1.2 The microprocessor RESET signal is derived from the Motherboard reset circuit. The clock signal is derived from MCC1, IC18, shown on page 7-11.

5.3.7.1.3 The microprocessor uses a multiplexed bus, the eight low-order bits being used for both address and data. The low-order address bits are put onto the bus first and are latched into IC11 by the address strobe. The bus is then free for data use.

5.3.7.1.4 Data transfer between the microprocessors is initiated by an interrupt and is controlled by a 3-wire handshake protocol. The transfer is in the form of a data string, the number of bytes in the string being indicated by the first byte.

5.3.7.2 Interface Description

5.3.7.2.1 There are two dual registers on board, U52 and U44 which latch the data and status bytes of each side (Interface uP and Wavetek 680 uP). Depending on which slot the 1993 is plugged into, the address will be compared to Module ID data (MID0-MID3) by U46. U51 is a Programmable Array Logic which decodes the address along with the control data such as AS, DS and W/R. After the address is decoded, the 680 uP will be able to read from the registers, write to the registers or read from U45 which is an EPROM. U45 contains the information regarding the front panel display and the specific codes that are needed for the handshake between the 680 uP and the 1993 counter.

5.3.7.2.2 When the 1993 is addressed in order to read data from the EPROM, U51-20 (ROMCS) and U51-14 (ROMSEL) will go low which enables the EPROM. After the EPROM is selected, it will put the 16 bit data on the internal bus which will go through the two buffers U55 and U56. The EN of the two buffers U56-19 and U55-19 will come from U51-17 upon the access of the 680 uP for read or write. The direction of the buffers, U55, U56-1 will be controlled by the R/W signal.

5.3.7.2.3 When the 1993 is addressed in order to be written into from the 680 uP, U51-15 (CLKVMEDATA) will toggle which puts a rising edge at U52 and U44-1 in order to clock the data from the 680 Bus into the registers U44, U52. Before this toggle the data is available long enough to meet the set-up time of the registers.

5.3.7.2.4 When the 1993 is addressed in order to be read, the OENVME signal (U51-16) will go low, which makes U44 and U52 registers put the data out onto the internal bus, and thru U56, U55 onto the 680 bus.

5.3.7.2.5 The 1993 interface uP is also capable of writing or reading from U44 and U52. U44 and U52 (74LS652) work so that each side can only read what the other side write. Therefore the 1993 interface uP can only read what the 680 uP wrote last into the U52 and U44 registers. The 1993 interface uP can only read a byte at a time. There are four control signals decoded through U50 which is a Programmable Logic Array, a Read/Write control signal, U50-14,15, for the status register U52 and a Read/Write control signal U50-16, 17 for the data register.

5.3.7.2.6 It is the same protocol for each of the uPs. Both uPs have to constantly read the status register until they see a byte that is required, then send data or receive the data. After that the handshake will begin by exchanging bytes through status and data registers.

5.3.7.2.7 At the end of each byte transfer a DTACK will be generated for the 680 uP to indicate the end of the receive or send message. DTACK is generated at U51-18, delayed through U50 and finally, from U50-20, will go into a high state and out onto the bus thru U53, which inverts the signal to low.

5.3.7.3 Data Transfer Between Microprocessors

5.3.7.3.1 Data transfer between microprocessors is made using the multiplexed data bus on both devices. Connections between the buses is made by means of a D-type latch, IC1 or IC2, depending on the direction of data transfer. All data transfers are initiated by the sending device. The first byte indicates the number of bytes to be transferred.

5.3.7.3.2 For data transfer to the Interface microprocessor, the instrument's microprocessor sets SK1 pin 22 (IFCSYSIRQ) low. This provides an interrupt request (IRQ) to the Interface microprocessor. As part of the interrupt routine, U40 is enabled and addressed to give an enabling signal for U37F. The microprocessor reads the IRQ flag via U37f and data bus line 7 to establish that the IRQ is from the instrument.

5.3.7.3.3 The Interface microprocessor prepares to receive data, and then enables and addresses U40 to give a signal which clocks U35B. The level set on line 0 of the data bus is transferred to U35B-5, and forms the ready for data (RFD) signal to the instrument's microprocessor.

5.3.7.3.4 The instrument's microprocessor enables and addresses U36 to give an enabling signal to U37C, reads the RFD signal, puts the first data byte on the bus, and readdresses U36 to give a clock signal which latches the data into U31. It then addresses U36 to give a clock signal for U35AA, so that the logic level set at U35A-12 is transferred to U35A-19 to form the data valid (DAV) signal to the 680 interface microprocessor.

5.3.7.3.5 The 680 interface microprocessor addresses U40 to give a signal to enable U37A and reads the DAV signal via data bus line 6. It then cancels its RFD signal,

addresses U40 to give an output enable signal for U31 and reads the data. A data accepted (DAC) signal is sent via U30 and the RFD signal is reset. The instrument's microprocessor responds by cancelling its DAV signal and entering the next data byte into U31. Data transfer continues in this manner until the required number of bytes have been received.

5.3.7.3.6 Data transfer from the 680 interface microprocessor to the instrument's microprocessor follows a similar pattern. The IRQ signal is passed from port A line 0 via U268 and U28. The IRQ flag is read by the instrument's microprocessor during its interrupt routine, via U37C (enabled by an output from U36). The IRQ signal is cancelled by the instrument's microprocessor setting data bus line 0 to logic 0 and then addressing U36 to clock U32A. The resulting logic 0 at U32A-9 disables U26-4.

5.3.7.3.7 During data transfer from the 680 interface to the instrument, the RFD signal is passed via U35A and U37f, the DAV signal via U35B and U37C, the DAC signal via U31, and the data via U30.

INTRODUCTION

- 1 This section provides information on the following:
 - (1) Required test equipment
 - (2) Dismantling and reassembly
 - (3) Diagnostic special functions
 - (4) Troubleshooting Flowcharts
 - (5) Instrument setup (either post-repair or after specification check failure)
 - (6) Overall specification check

REQUIRED TEST EQUIPMENT

- 2 A complete list of required test equipment is provided in Table 6.1 on the next page. Equipment needed for specific procedures is indicated at the beginning of each set of instructions.
- 3 Particular models of specific equipment types are recommended in some categories. However, equipment having operating characteristics equivalent to or better than those listed may be substituted. The procedures described in this section are general ones and based on the use of the test equipment recommended. Some modification to the procedures may be necessary if substituted equipment is used.

TABLE 6.1
Required Test Equipment

Item	Minimum Use Specification	Recommended Equipment
1. Frequency Standard	10 MHz; accuracy better than ± 3 parts in 10^{10}	Racal-Dana 9475
2. Oscilloscope with an X1 probe	50 MHz bandwidth	TEK 454
3. Digital Multimeter	Frequency range of DC to 5 kHz; input level of 20 mV to 6V	Racal-Dana 5001
4. Signal Generator	10 kHz to 1.3 GHz	Racal-Dana 9087
5. Audio Generator	Frequency range of 10 Hz to 5 kHz; output level of 30 mV into 50 ohms	Racal-Dana 9085
6. Pulse Generator	Single positive-going pulse with +0.8V low and +2.8V high levels (TTL limit-level)	Racal-Dana 1515
7. BNC T-Connector	50 ohms	
8. Connector Lead	50-ohm coaxial cable with BNC connectors, length between 0.80m and 1m	
9. Coaxial Load	BNC connector, 50 ohms	

DISASSEMBLY INSTRUCTIONS

- 4 Remove the four panhead screws that secure the 1993 rear cover to the rear of the counter. Remove the cover.
- 5 Slide the side cover along its channel in the 1993 chassis, towards the rear of the counter, and remove the side cover.
- 6 If Option 41, (Channel C) is fitted, disconnect the coax cable from the Channel C board to the 1993 front panel at the front panel.
- 7 Remove the four countersunk screws that retain the 1993 PCB to the chassis. Slide the PCB towards the rear of the chassis and remove the PCB.
- 8 Disassembly is now complete.

REASSEMBLY INSTRUCTIONS

- 9 Align the counter PCB with its channel in the 1993 chassis. Slide the PCB into the chassis.
- 10 Secure the PCB to the chassis with the four countersunk screws obtained on disassembly.
- 11 If Option 41 (Channel C) is fitted, connect the coax cable from the Channel C board to the Input C connector on the front panel.
- 12 Align the 1993 side cover with its channel in the 1993 chassis. Slide the cover into the chassis.
- 13 Align the 1993 rear cover with the rear of the chassis. Secure the rear cover to the chassis with the four panhead screws obtained on disassembly.
- 14 Reassembly is now complete.

DIAGNOSTIC SPECIAL FUNCTIONS

- 15 Refer to Section 3 and Table 3.3 for a full description of the counter's special functions. Listed below in Table 6.2 are those special function numbers for use during maintenance and calibration. To use these special functions Check Mode must be selected and then the special function enabled.

TABLE 6.2
Diagnostic Special Functions

Function Number	Function
70	Basic 10 MHZ check (default)
72	Start TEC (Timing Error Correction) short, continuous calibration. Application of a 100 ns pulse with TEC count shown on display
73	Start TEC long, continuous calibration. Application of a 200 ns pulse with TEC count shown on display
74	Stop TEC short calibration
75	Stop TEC long calibration
76	Input A and B DAC check with continuous ramping through the DACs
77	Input A relay check
78	Input B relay check

16 Special Function 70

Special function 70 is the default state of its decade. It provides measurement of the 10 MHz internal frequency standard and verifies operation of the microprocessor system, MCC1, MCC2 and the TEC circuits.

17 Special Functions 72, 73, 74 and 75

Special functions 72, 73, 74 and 75 should only be used for diagnostic purposes at an ambient temperature of $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$.

- 18 The TEC long counts must be 800 ± 220 . The TEC short counts must be in the range $(0.5 \times \text{long count}) + 20$ to -40 . Counts outside these ranges indicate a malfunction of the TEC circuit.

19 Special Function 76

Special function 76 continuously exercises the DACs in both Channel A and Channel B through the range -5.1V to $+5.1\text{V}$. The waveform can be monitored at test point TPA and TPB on the counter PCB.

20 Special Function 77

Special function 77 continuously tests the relays associated with Channel A input: X1/X10 attenuators, 50Ω / $1M\Omega$ input impedance, DC/AC coupling, FILTER and COM A. A 10 MHz TTL signal must be applied to input A.

21 Special Function 78

Special function 78 continuously tests the relays associated with Channel B input: X1/X10 attenuators, 50Ω / $1M\Omega$ input impedance and DC/AC coupling. A 10 MHz TTL signal must be applied to input B.

22 Special Function Error Codes

Listed below in Table 6.3 are displayed error codes for the diagnostic Special Functions.

TABLE 6.3

Special Function Error Codes

Display	Special Function Number	Error
Er 50	70	Basic CHECK mode error
Er 51	77	Input A relay check { X10/X1 50 Ω /1m Ω DC/AC FILTER COM A
Er 52		
Er 53		
Er 54		
Er 55		
Er 56	78	Input B relay check { X10/X1 50 Ω /1m Ω DC/AC
Er 57		
Er 58		

TROUBLESHOOTING FLOWCHARTS

Introduction

- 23 Refer to Fig 6.1 for troubleshooting flowcharts. They are designed to facilitate the user in tracing specific 1993 faults and failures to their sources.

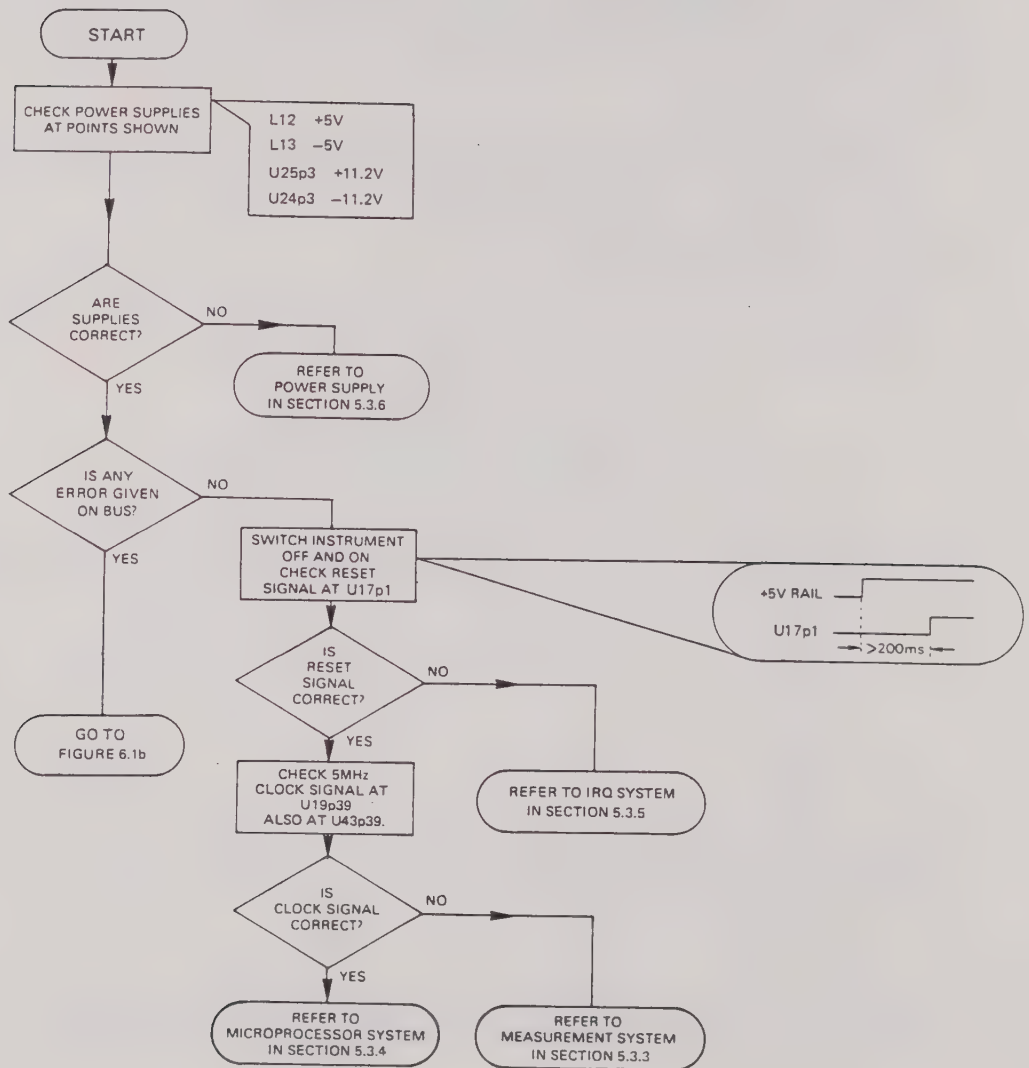


Fig. 6.1a - 1993 Troubleshooting Flowchart

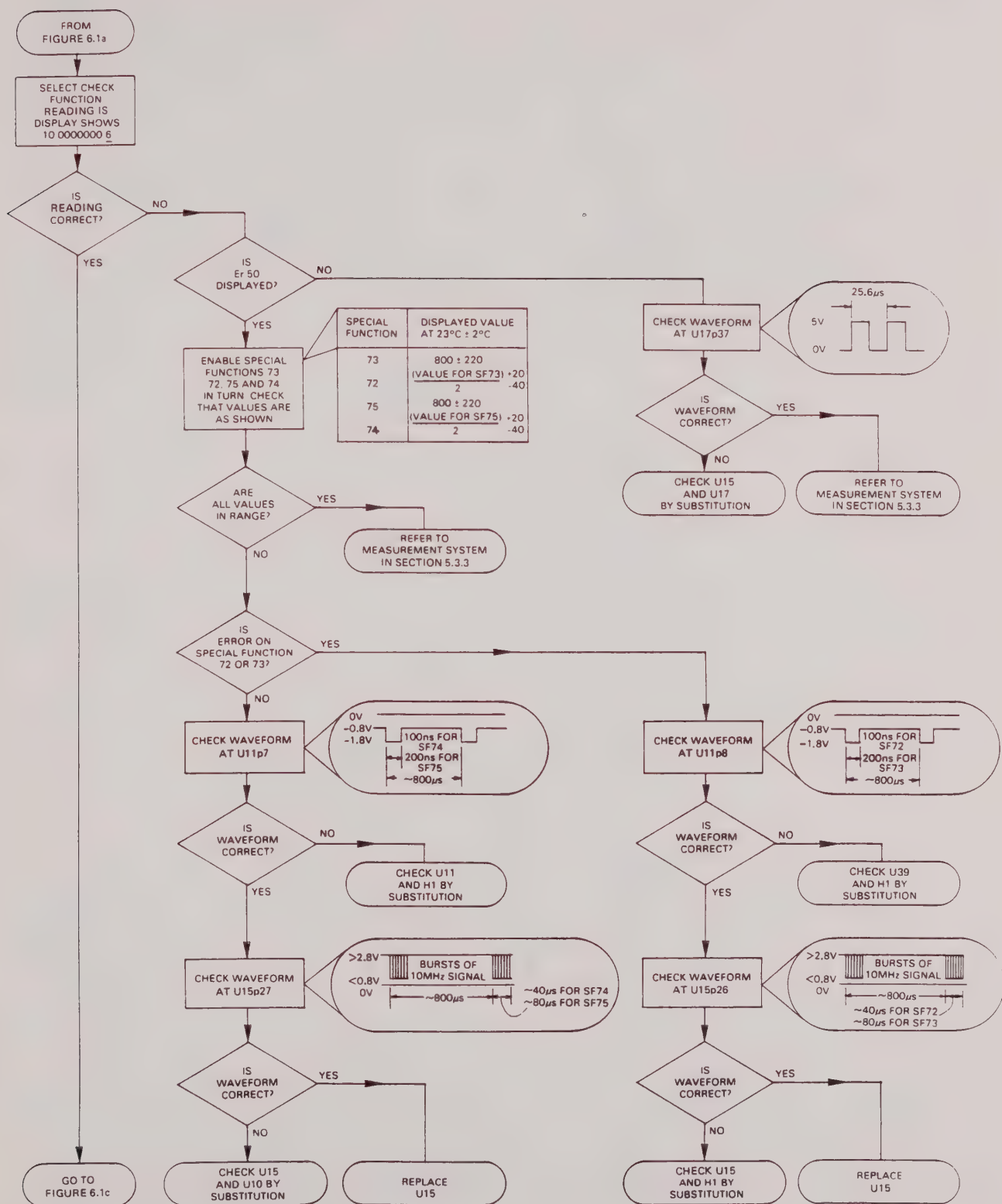


Fig. 6.1b - 1993 Troubleshooting Flowchart (Cont'd)

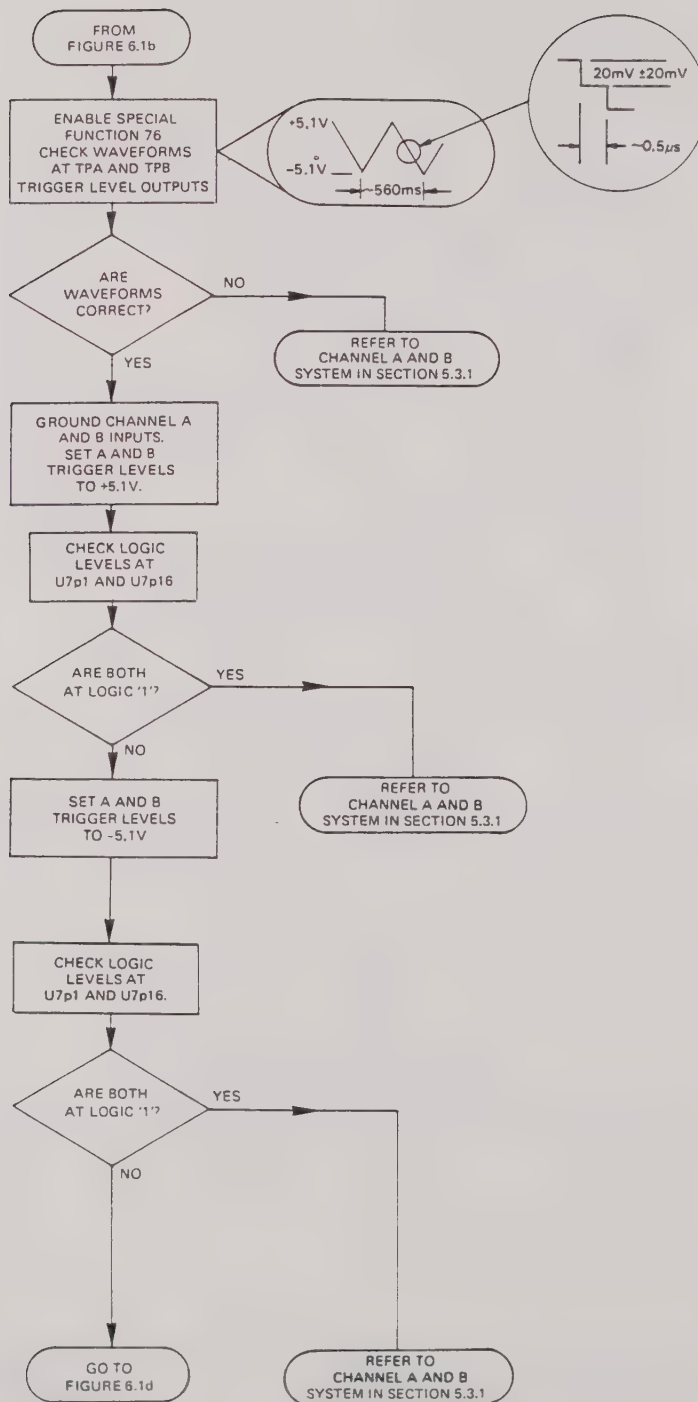


Fig. 6.1c - 1993 Troubleshooting Flowchart (Cont'd)

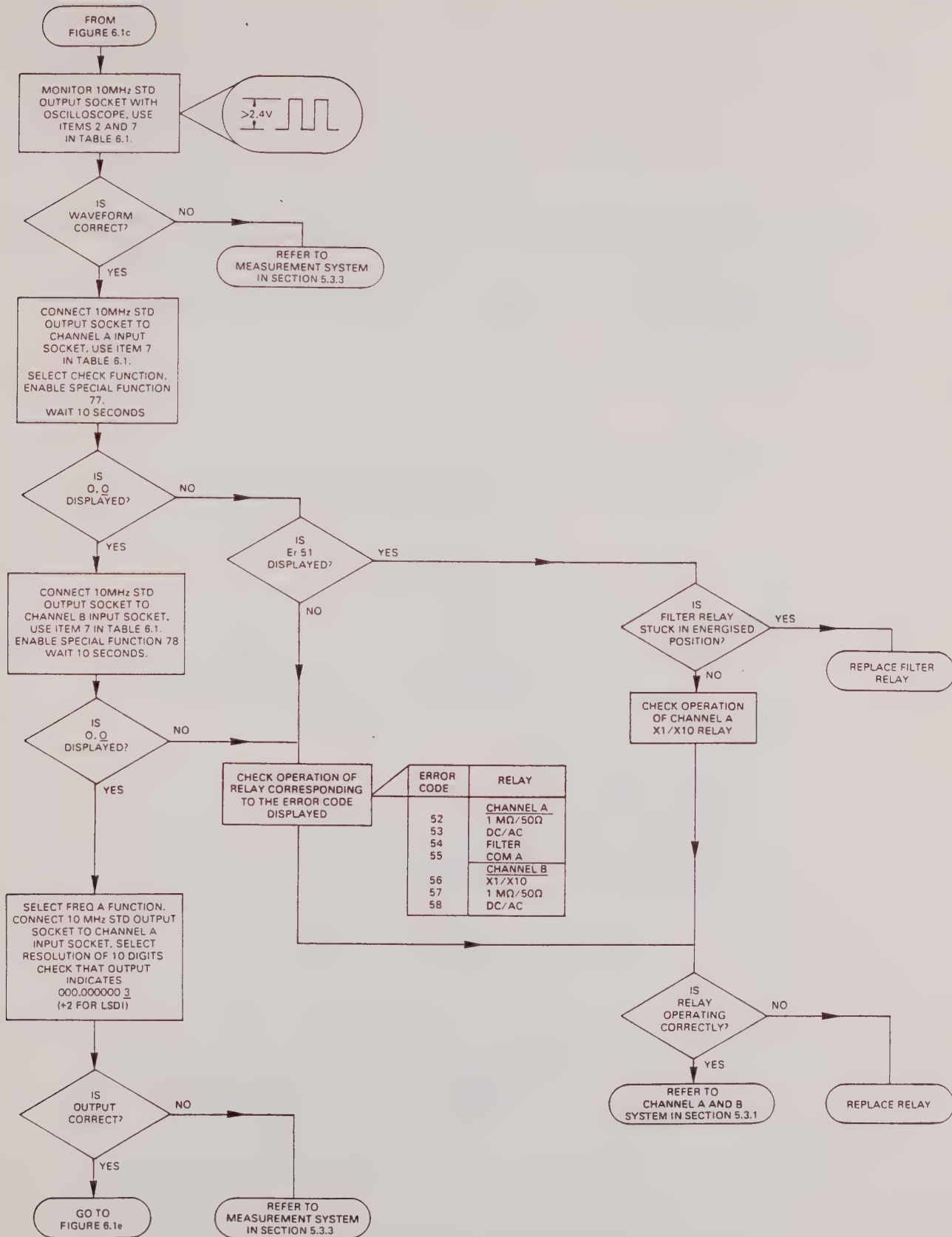


Fig. 6.1d - 1993 Troubleshooting Flowchart (Cont'd)

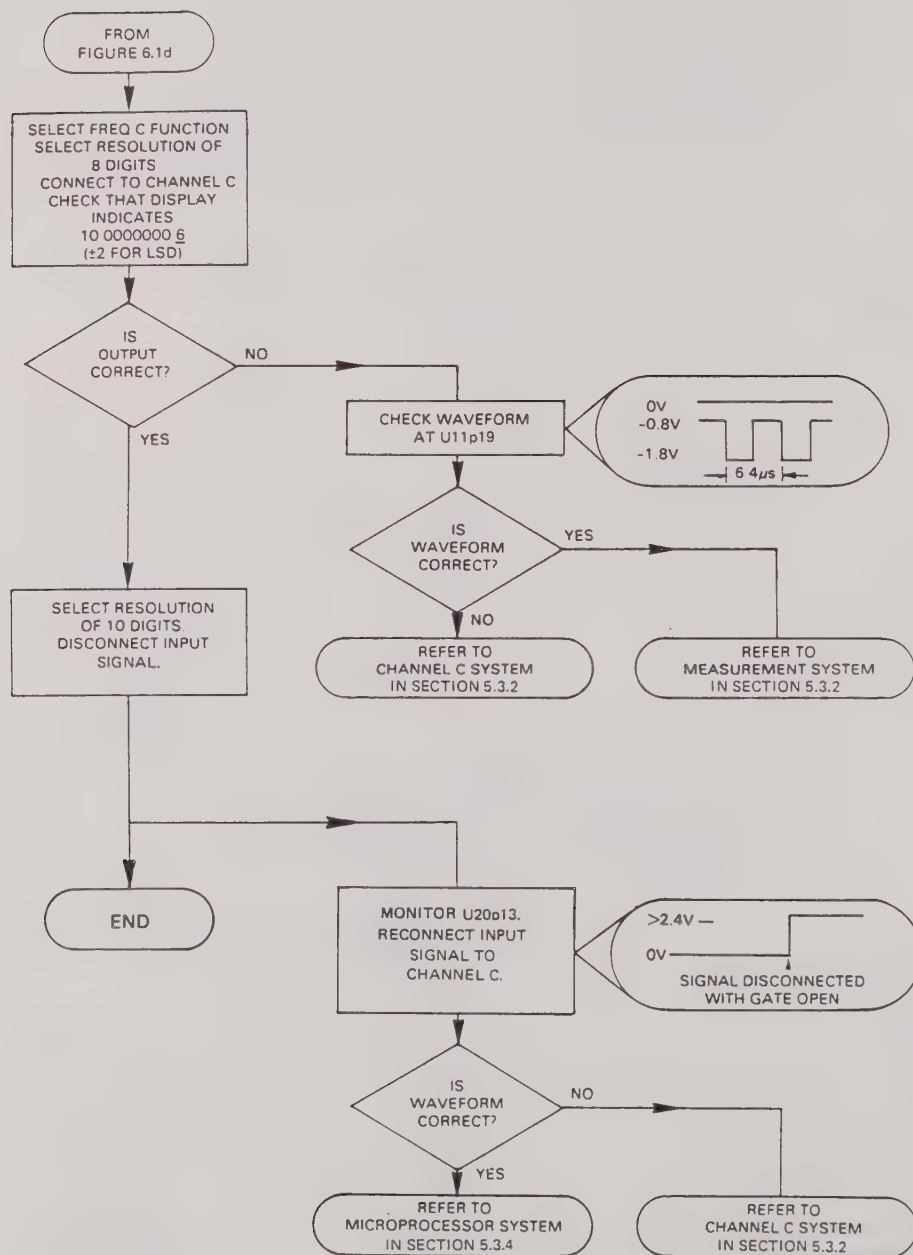


Fig. 6.1e - 1993 Troubleshooting Flowchart (Cont'd)

COUNTER SETUP (POST-REPAIR/POST-SPECIFICATION CHECK FAILURE)

Introduction

- 24 After repair, appropriate setup procedures as described in this subsection should be performed prior to initiating an overall specification check. These procedures should also be used if the counter fails a routine specification check.
- 25 The ambient temperature must be maintained at $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ throughout the procedures. The instrument should be powered from an AC supply, not a battery pack.

Channel A Input System

- 26 Required test equipment includes a signal generator (See Table 6.1, Item 4)
- 27 First, set R16 fully counterclockwise and R11 to its midposition. R11 and R16 are located inside the screened module, as shown in Fig 6.2.

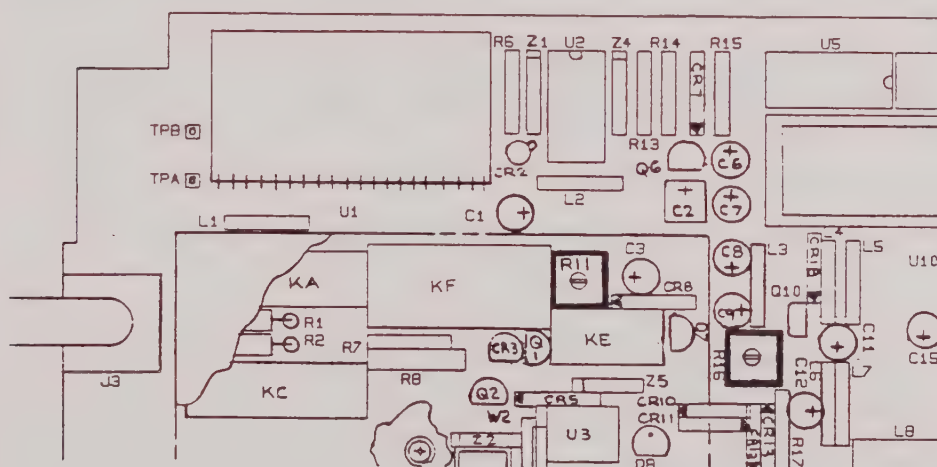


Fig. 6.2 Location of R16 and R11

- 28 Complete the following procedure:
 - (1) Switch the 680 on. Select function FREQ A.
 - (2) Select 50 ohms impedance for channel A.
 - (3) Set the RESOLUTION to 3 digits.
 - (4) Connect the test equipment as shown in Fig 6.3.

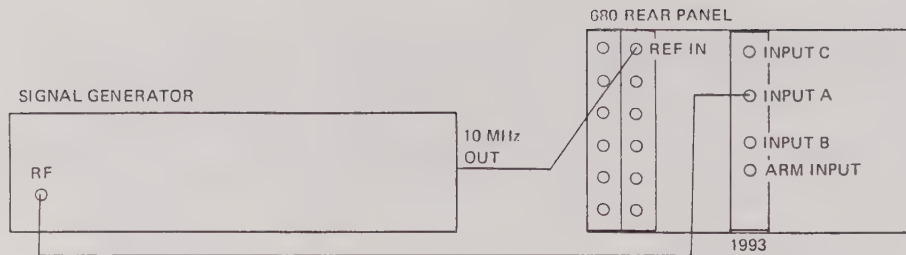


Fig. 6.3 Connections for Channel A Input System Adjustment

- (5) Set the signal generator output to 100 MHz at a level of 3.0 MV rms.
- (6) Adjust R11 to obtain the most stable output indication of 100.0 6 $\pm$ 0.1 6.

NOTE:

Care is required when adjusting R11. The display indication is random when R11 is set to either side of its correct position.

29 Complete the following procedure:

- (1) Switch off the RF output of the signal generator
- (2) Set the RESOLUTION to 6 digits.
- (3) Switch on the RF output of the signal generator.
- (4) Increase the generator's output to 13 mV rms.
- (5) Adjust R16 slowly clockwise until the output just becomes unstable. Turn back until the output is just stable, and indicates 100.000000 6 $\pm$ 0.000001 6.
- (6) Reduce the generator's output to 7 mV rms. If the GATE LED continues to flash, repeat steps 4 through 6.
- (7) Switch off the 680 and disconnect the test equipment.

Channel B Input System

- 30 Required test equipment includes a signal generator (See Table 6.1; Item 4). equipment required:
- 31 Set R19 fully counterclockwise and R12 to its midposition. R12 is located inside the screened module as shown in Fig 6.4.

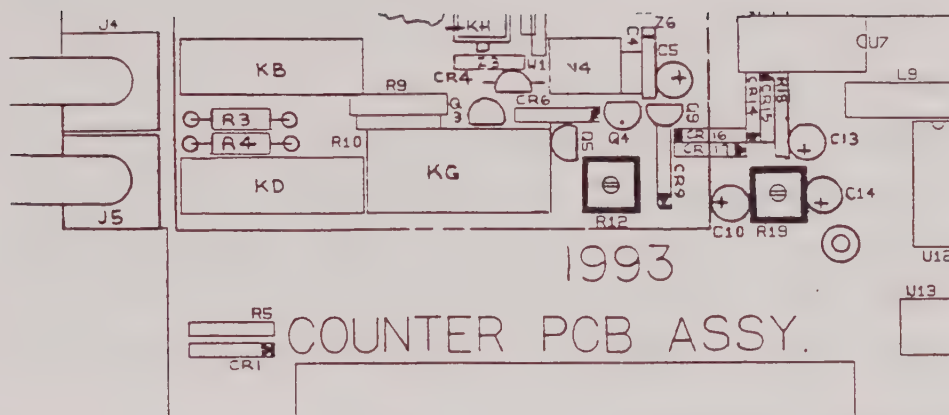


Fig 6.4 Location of R19 and R12

32 Complete the following procedure:

- (1) Switch the 680 on. Select function FREQ B.
- (2) Select 50 ohms impedance for channel B.
- (3) Set the RESOLUTION to 4 digits.
- (4) Connect the test equipment as shown in Fig. 6.5.

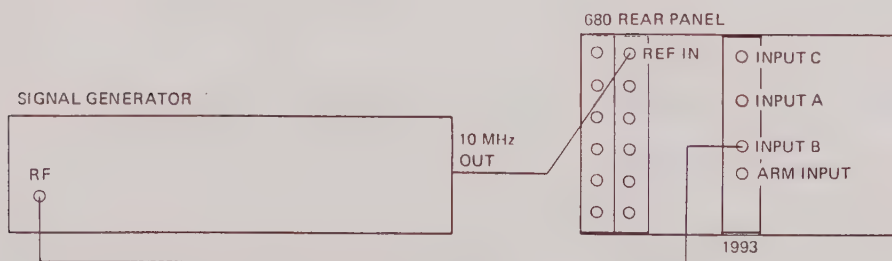


Fig 6.5 Connections for Channel B Input System Adjustment

- (5) Set the signal generator output to 100 MHz at a level of 3.0 mV rms.
- (6) Adjust R12 to obtain the most stable output indication of 100.0 ± 0.1 .

NOTE:

Care is required when adjusting R12. The display indication is random when R12 is set to either side of its correct position.

33 Complete the following procedure:

- (1) Switch off the RF output of the signal generator.
- (2) Set the RESOLUTION to 8 digits.
- (3) Switch on the RF output of the signal generator.
- (4) Increase the signal generator's output to 13 mV rms.
- (5) Adjust R19 slowly clockwise until the output just becomes unstable. Turn back until the output is just stable, showing $100.000000 \underline{6} \pm 0.000001 \underline{6}$.
- (6) Reduce the signal generator's output to 7 mV rms. If the GATE LED continues to flash, repeat steps 4 through 6.
- (7) Switch off the 680 and disconnect the test equipment.

Channel C Assembly 19-1142

- 34 Required test equipment includes a signal generator and connector lead (see Table 6.1; Items 4 and 8).
- 35 Connect the test equipment as shown in Fig. 6.6.

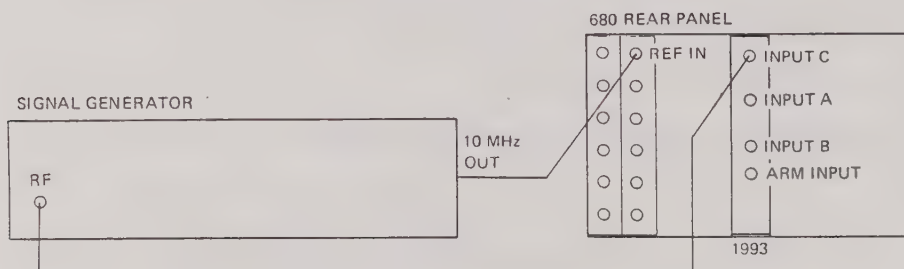


Fig. 6.6 Connections for Channel C Input System Adjustment

36 Complete the following procedure:

- (1) Set R27 on Assembly 11-1142 fully clockwise.
- (2) Switch the 680 on. Select function FREQ C.
- (3) Set the signal generator output to 1 GHz at a level of 5.0 mV rms.
- (4) Adjust R27 until 1993 output indicates $1000.00000 \underline{6} \pm 0.00001 \underline{E6}$.
- (5) Switch the output of the signal generator off. Decrease the output level to 4.5 mV rms.
- (6) Switch the output of the signal generator on. Verify that the 1993 is not counting. If it is, repeat steps 3 through 6.
- (7) Switch off the 680 and disconnect the test equipment.

OVERALL SPECIFICATION CHECK

Introduction

- 37 Satisfactory completion of the following performance verification procedures (PVPs) will confirm that the instrument is functional and meets its specification. Before beginning the specification check, ensure that the instrument successfully passes the functional check provided in Section 2.6 of this manual. The PVPs should be completed in the order given.
- 38 The following conditions must be kept throughout the specification check:
- (1) The line voltage must be within the indicated range of the line voltage selector.
 - (2) The instrument covers must be installed.
 - (3) The ambient temperature must be $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$.

Channel A Sensitivity PVP

- 39 Required equipment includes a digital multimeter, signal generator, audio oscillator and BNC T-Connector (see Table 6.1; Items 3, 4, 5, and 7).
- 40 Complete the following procedure:
- (1) Switch on the 680. Select 50 ohms for Input A.
 - (2) Connect the test equipment as shown Fig 6.7.

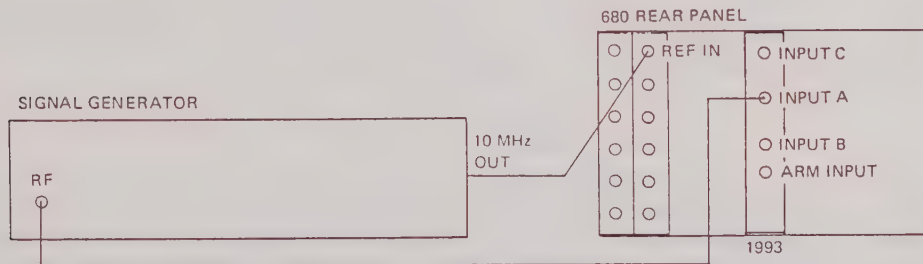


Fig 6.7 Connections for Channel A Sensitivity PVP (I)

- (3) Set, in turn, the signal generator output to the frequencies shown in Table 6.4. Set the 1993 resolution to the corresponding value.

TABLE 6.4

Channel A Sensitivity (I)

Frequency	1993 Resolution	Signal Level	Result
160 MHz	8 digits	40 mV	160 MHz $\pm$ 1 Hz
100 MHz	8 digits	20 mV	100 MHz $\pm$ 2 Hz
10 MHz	7 digits	20 mV	10 MHz $\pm$ 0.2 Hz
100 KHz	5 digits	20 mV	100 KHz $\pm$ 0.02 Hz

- (4) For each selected frequency, determine the minimum input level to the 1993 counter that provides stable counting. Verify that these minimum levels do not exceed those shown in the table.
- (5) Disconnect the test equipment.

41 Complete the following procedure:

- (1) Connect the test equipment as shown in Fig. 6.8.

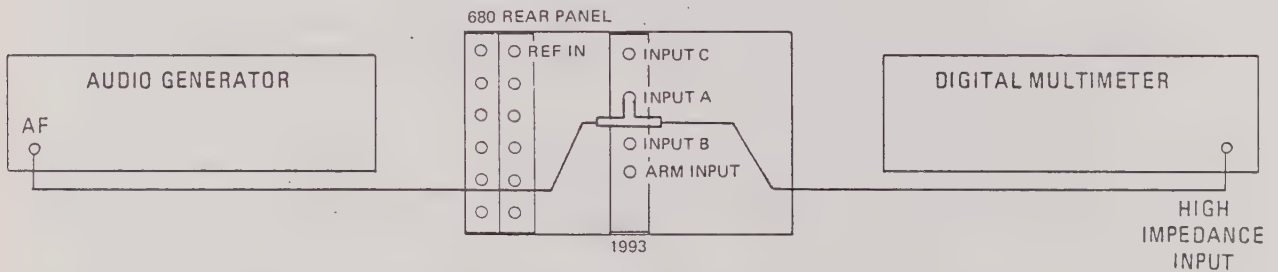


Fig. 6.8 Connections for Channel A Sensitivity PVP (II)

- (2) Set, in turn, the signal generator output to the frequencies shown in Table 6.5. Set the 1993 resolution to the corresponding value.

TABLE 6.5

Channel A Sensitivity (II)

Frequency	Counter Resolution	Signal Level	Result
5 KHz	3 Digits	20 mV	5 KHz $\pm$ 0.24 Hz
10 Hz	3 Digits	20 mV	10 Hz $\pm$ 1.7 Hz

- (3) For each selected frequency, determine the minimum input level to the counter that provides stable counting. Verify that these minimum levels do not exceed those shown in the table.
- (4) Disconnect the test equipment.

Channel B Sensitivity PVP

- 42 Required equipment includes a digital multimeter, signal generator, audio generator, and BNC T-Connector (see Table 6.1; Items 1, 3, 5, and 8).
- 43 Complete the following procedure:
 - (1) Select 50 ohms for channel B and Frequency B.
 - (2) Connect the test equipment as shown in Fig. 6.9.

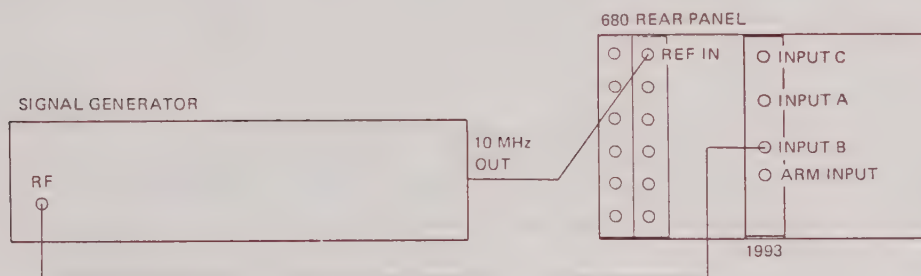


Fig. 6.9 Connections for Channel B Sensitivity PVP (I)

- (3) Set, in turn, the signal generator output to the frequencies shown in Table 6.6. Set the 1993 resolution to the corresponding values.

TABLE 6.6

Channel B Sensitivity (I)

Frequency	Counter Resolution	Signal Level	Result
100 MHz	8 digits	20 mV	100 MHz $\pm$ 2Hz
10 MHz	7 digits	20 mV	10 MHz $\pm$ 0.2 Hz
100 KHz	5 digits	20 MV	100 KHz $\pm$ 0.02 Hz

- (4) For each selected frequency, determine the minimum input level to the 1993 that provides stable counting. Verify that these minimum levels do not exceed those shown in the table.
 - (5) Disconnect the test equipment.
- 44 Complete the following procedure:

- (1) Connect the test equipment as shown in Fig. 6.10.

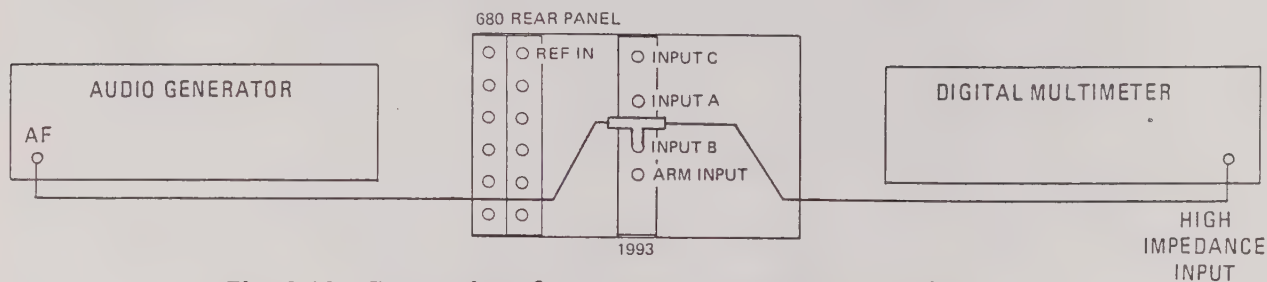


Fig. 6.10 Connections for Channel B Sensitivity PVP (II)

- (2) Set, in turn, the signal generator output to the frequencies shown in Table 6.7. Set the 1993 resolution to the corresponding values.

TABLE 6.7

Input B Sensitivity (II)

Frequency	Counter Resolution	Signal Level	Result
5 Kz	3	20 mV	5 KHz $\pm$ 0.24 Hz
10 Hz	3	20 mV	10 Hz $\pm$ 1.7 Hz

- (3) For each selected frequency, determine the minimum input level to the 1993 that provides stable counting. Verify that these minimum levels do not exceed those shown in the table.
- (4) Turn off and disconnect the test equipment.

Channel C Sensitivity PVP (Option 41 only)

- 45 Required equipment includes a signal generator and connector lead (see Table 6.1; Items 1 and 7).
- 46 Complete the following procedure:
 - (1) Connect the test equipment as shown in Fig. 6.11.

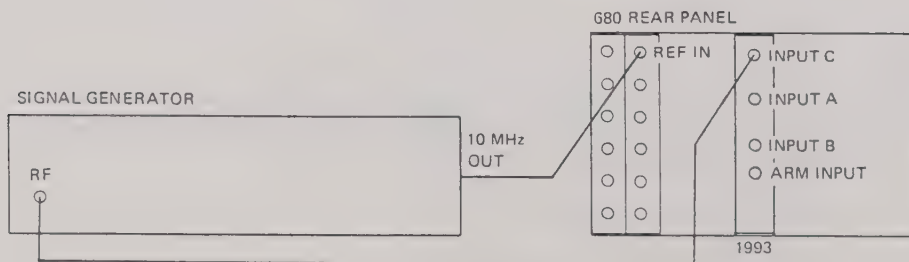


Fig. 6.11 Connections for Channel C Sensitivity PVP

- (2) Select function FREQ C.
- (3) Set, in turn, the signal generator output to the frequencies shown in Table 6.8. Set the 1993 resolution to the corresponding values.

TABLE 6.8
Channel C Sensitivity

Frequency	Counter Resolution	Signal Level	Result
40 MHz	8 digits	8.5 mV	40 MHz $\pm$ 0.4 Hz
100 MHz	8 digits	8.5 mV	100 MHz $\pm$ 1 Hz
500 MHz	8 digits	8.5 mV	500 MHz $\pm$ 5 Hz
1.0 GHz	9 digits	8.5 mV	1 GHz $\pm$ 1 Hz
1.3 GHz	9 digits	70 mV	1.3 GHz $\pm$ 2 Hz

- (4) For each selected frequency, determine the minimum input level to the 1993 that provides stable counting. Verify that these minimum levels do not exceed those shown in the table.
- (5) Disconnect the test equipment.

Minimum Time Interval PVP

- 47 Required test equipment includes a signal generator (see Table 6.1; Item 4).
- 48 Complete the following procedure:
 - (1) Connect the signal generator as shown in Fig. 6.12.

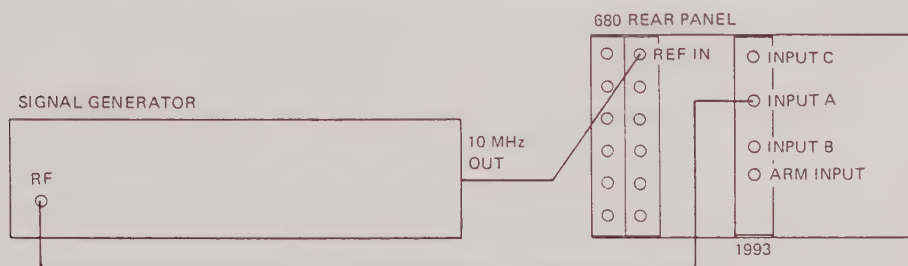


Fig. 6.12 Connections for Minimum Time Interval PVP

- (2) Select 50 ohms on channel A, function TI A $\rightarrow$ B, and COM A.
- (3) Set the signal generator output to 100 MHz at a level of 1V.
- (4) Verify that a display of 0 ± 2 ns is obtained.
- (5) Disconnect the test equipment.

External Arming PVP

- 49 Required test equipment includes a signal generator and pulse generator (see Table 6.1; Items 4 and 6).
- 50 Complete the following procedure:
 - (1) Select 50 ohms on channel A and function FREQ A. Set the RESOLUTION to 5 digits.
 - (2) Connect the test equipment as shown in Fig. 6.13.

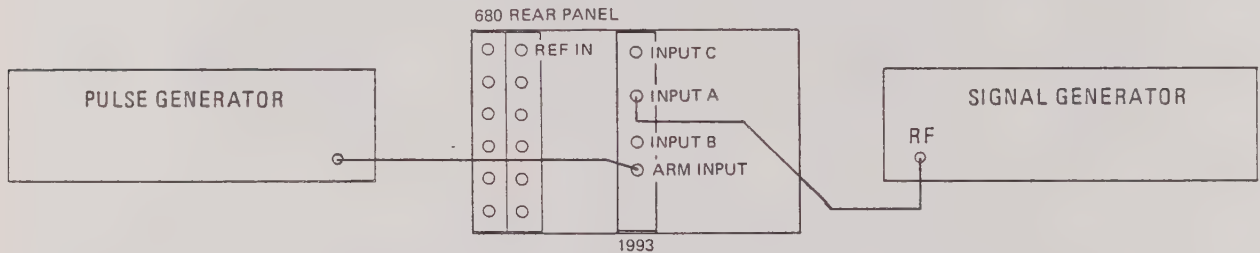
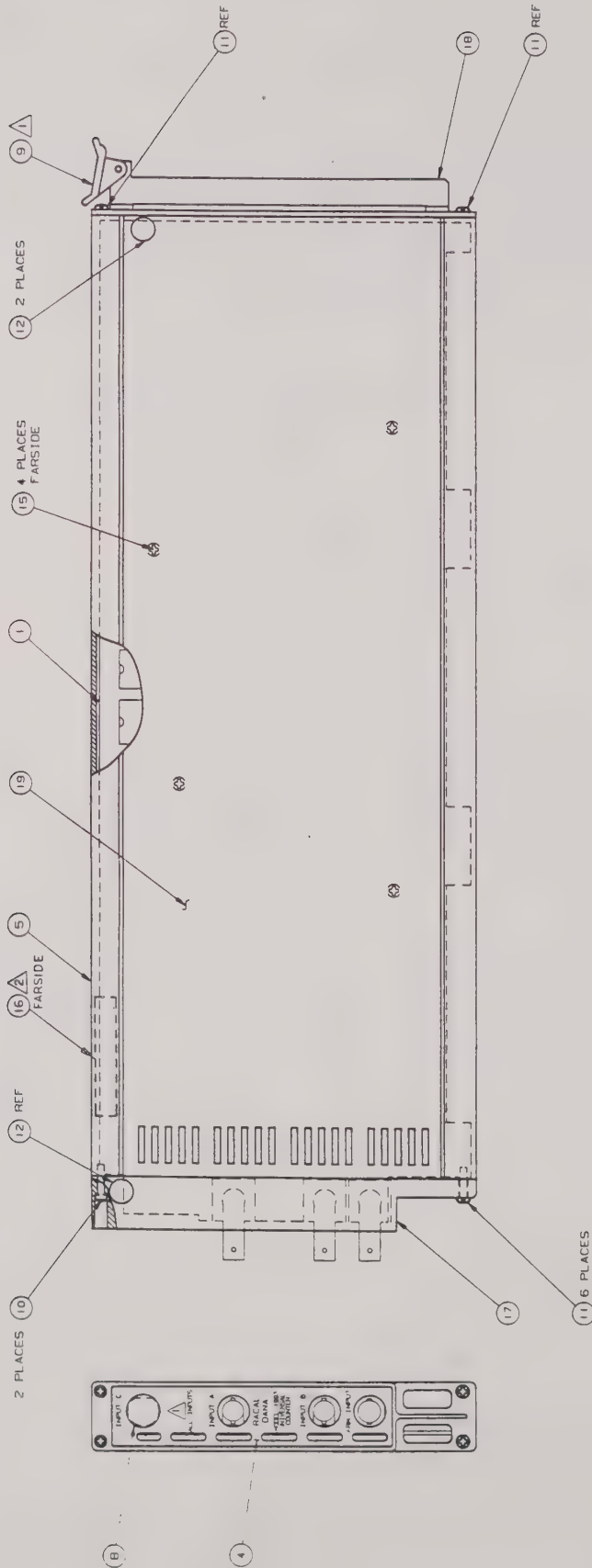


Fig. 6.13 Connections for External Arming PVP

- (3) Set the signal generator output to 10 MHz at a level of 250 mV rms.
- (4) Prepare the pulse generator to provide a single, 300 us, positive-going pulse with a low level of +0.4V and a high level of +2.4V (TTL-limit levels).
- (5) Verify that the instrument is not counting.
- (6) Trigger the pulse generator to obtain a single pulse output.
- (7) Verify that the output indicates 10.0000 6 Hz $\pm$ 1 count and that the counter is not continuously gating.
- (8) Disconnect the test equipment.

404585	Module Assembly, 1993	7-2
404608	Module Assembly, 1993/41.....	7-3
401854	VME PCB Assembly	7-4
431854	VME Schematic	7-6
404626	Channel C PCB Assembly	7-19
R-19-1142	Channel C Schematic	7-20

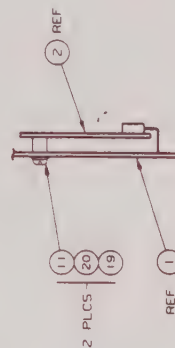


DOC NO		404
RACAL-DANA Instruments Inc.		
4 GOODYEAR, IRVINE, CALIFORNIA 92714		
DOCUMENT TITLE		MODULE ASSY, 1993
SIZE	CODE IDENT NO	REV
D	21793	A
SCALE 1/1	SHEET 1	OF 2

△ TYPE PERTINENT DATA ON SERIAL NO. TAG, ATTACH TAG APPROXIMATELY WHERE SHOWN.

△ ROLL PIN SUPPLIED WITH EJECTOR (ITEM 9). ROLL PIN MATES FLUSH TO EJECTOR SURFACE.

NOTES: UNLESS OTHERWISE SPECIFIED

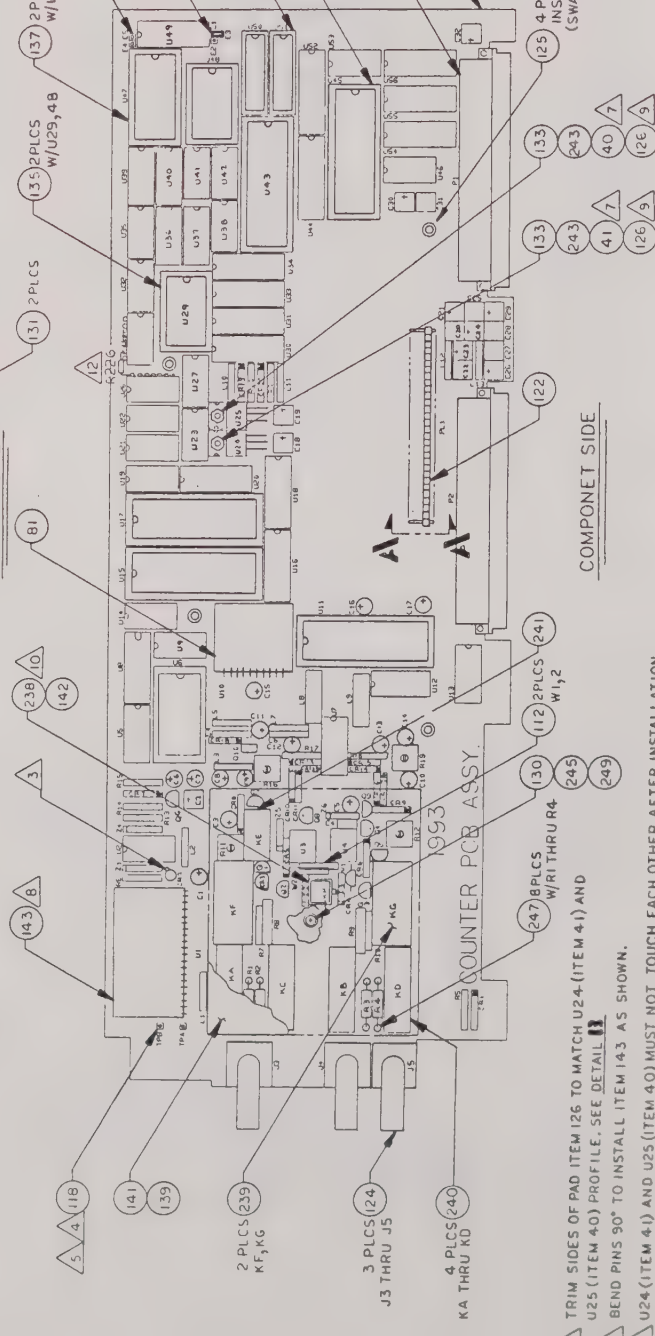


DOC NO		404603	
RIACAL-DANA Instruments Inc. 4 GOODYEAR, IRVINE, CALIFORNIA 92714			
DOCUMENT TITLE			
MODULE ASSY, 1993/41			
SIZE	CODE IDENT NO	DOCUMENT NO	REV
D	21793	404608	A
SCALE 1/1	SHEET 1	OF 2	

031113JDS J51M1110 553 INT 31C04



CIRCUIT SIDE



COMPONENT SIDE

COUNTER PCB ASSY.

SECTION A-A
SCALE: NONE

PROPRIETARY NOTICE
THIS DOCUMENT IS THE PROPERTY OF RACAL-DANA INSTRUMENTS INC. AND IS NOT TO BE REPRODUCED OR TRANSMITTED IN ANY FORM OR BY ANY MEANS, ELECTRONIC OR MECHANICAL, INCLUDING PHOTOCOPYING, RECORDING, OR BY ANY INFORMATION STORAGE AND RETRIEVAL SYSTEM. ANY UNAUTHORIZED REPRODUCTION OR TRANSMISSION OF THIS DOCUMENT IS PROHIBITED. RACAL-DANA INSTRUMENTS INC. MAY ONLY BE USED FOR PURPOSES OF ENGINEERING OR MANUFACTURE BY ANYONE OTHER THAN RACAL-DANA INSTRUMENTS INC. FOR THE PRODUCTION OF PRODUCTS FROM WHICH SPECIFIC PROCUREMENT OF PRODUCTS FROM RACAL-DANA INSTRUMENTS INC.

RACAL-DANA Instruments Inc.			
4 GOODYEAR, IRVINE, CALIFORNIA 92714			
DOCUMENT TITLE			
PCB ASSY, 1993 COUNTER			
SIZE	CODE IDENT NO	DOCUMENT NO	REV
D	21793	401854	H
SCALE 1:1	SHEET 1		OF 6

- 12 INSTALL R222 AS CLOSE AS POSSIBLE TO U26 AND U28.
11 TRIM 3 SOLDER TABS ON ITEM 147 ADJACENT TO BNC CONNECTORS TO 0.020 MAX.
10 ATTACH WIRE (ITEM 113) FROM RELAY CASE KH (ITEM 238) TO GND HOLE ON PCB NEXT TO STANDOFF.

- 9 TRIM SIDES OF PAD ITEM 126 TO MATCH U24 (ITEM 41) AND U25 (ITEM 40) PROFILE. SEE DETAIL B.
8 BEND PINS 90° TO INSTALL ITEM 143 AS SHOWN.
7 U24 (ITEM 41) AND U25 (ITEM 40) MUST NOT TOUCH EACH OTHER AFTER INSTALLATION.
6 INSTALL Q101 THRU Q104 (ITEM 234) WITH COMPONENT NOMENCLATURE VISIBLE.
5 INSTALL WITH SHORT PINS IN PCB, ITEM 116 AND 118 TO BE PERPENDICULAR AND FIRMLY SEATED ON PCB AFTER SOLDERING.
4 ITEM 118 SPLIT INTO 3 SECTIONS FOR E3, TPA AND TP8.
3 INSTALL CR2 (ITEM 54) 10-15 HIGH ABOVE PCB.
2 TRANSISTORS Q1 THRU Q10, CR3, AND CR4 MUST BE INSTALLED .35-.45 HIGH ABOVE PCB.
1 REFERENCE SCHEMATIC 431854.

NOTES: UNLESS OTHERWISE SPECIFIED

U23, 44	2016	24	12
U20	74HC1244	20	10
U15	22-8403HCC1	1	16, 36
U11	10315	1	1, 16
U12	10315	1	1, 16
U13	10-6199HCC2	10, 31	40
U10	74C1034	2	7, 9
U14	74C1034	3	3, 5, 35, 14
U2	LM339	1	11, 3
U1	HYBRIO-DAC	9	11, 3
U3	U56	20	10
U4	74LS245	20	10
U5	2V1012	24	12
U50, 51	2V1012	24	12
U45	27C1024	40	11, 30
U46	27C1024	40	11, 30
U47	680513	14	20
U17, 43	680513	14	20
U8, 49	74HC1373	20	10
U23	74HC102	14	7
U24	74HC102	14	7
U25	74HC102	14	7
U26	74HC102	14	7
U27, 32, 33, 34	74HC174	20	10
U28	74HC174	14	7
U29	74HC100	14	7
U30	74HC100	14	7
U31	74LS27	14	7
U32	74LS27	14	7
U33	74LS27	14	7
U34	74LS27	14	7
U35	74LS27	14	7
U36	74LS27	14	7
U37	74LS27	14	7
U38	74LS27	14	7
U39	74LS27	14	7
U40	74LS27	14	7
U41	74LS27	14	7
U42	74LS27	14	7
U43	74LS27	14	7
U44	74LS27	14	7
U45	74LS27	14	7
U46	74LS27	14	7
U47	74LS27	14	7
U48	74LS27	14	7
U49	74LS27	14	7
U50	74LS27	14	7
U51	74LS27	14	7
U52	74LS27	14	7
U53	74LS27	14	7
U54	74LS27	14	7
U55	74LS27	14	7
U56	74LS27	14	7
U57	74LS27	14	7
U58	74LS27	14	7
U59	74LS27	14	7
U60	74LS27	14	7
U61	74LS27	14	7
U62	74LS27	14	7
U63	74LS27	14	7
U64	74LS27	14	7
U65	74LS27	14	7
U66	74LS27	14	7
U67	74LS27	14	7
U68	74LS27	14	7
U69	74LS27	14	7
U70	74LS27	14	7
U71	74LS27	14	7
U72	74LS27	14	7
U73	74LS27	14	7
U74	74LS27	14	7
U75	74LS27	14	7
U76	74LS27	14	7
U77	74LS27	14	7
U78	74LS27	14	7
U79	74LS27	14	7
U80	74LS27	14	7
U81	74LS27	14	7
U82	74LS27	14	7
U83	74LS27	14	7
U84	74LS27	14	7
U85	74LS27	14	7
U86	74LS27	14	7
U87	74LS27	14	7
U88	74LS27	14	7
U89	74LS27	14	7
U90	74LS27	14	7
U91	74LS27	14	7
U92	74LS27	14	7
U93	74LS27	14	7
U94	74LS27	14	7
U95	74LS27	14	7
U96	74LS27	14	7
U97	74LS27	14	7
U98	74LS27	14	7
U99	74LS27	14	7
U100	74LS27	14	7

25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100

PROPRIETARY NOTICE

THIS DOCUMENT AND THE TECHNICAL DATA HEREON DISCLOSED ARE PROPRIETARY TO RACAL-DANA INSTRUMENTS INC. NO PART OF THIS DOCUMENT OR THE TECHNICAL DATA HEREON DISCLOSED ARE TO BE REPRODUCED, COPIED, OR TRANSMITTED IN ANY FORM OR BY ANY MEANS, ELECTRONIC OR MECHANICAL, INCLUDING PHOTOCOPYING, RECORDING, OR BY ANY INFORMATION STORAGE AND RETRIEVAL SYSTEM, WITHOUT THE WRITTEN PERMISSION OF RACAL-DANA INSTRUMENTS INC. BE USED, RELEASED OR DISCLOSED IN WHOLE OR IN PART, OR USED TO SOLICIT QUOTATIONS FROM A COMPETITIVE SOURCE, OR USED FOR MANUFACTURE BY ANY OTHER ENTITY, WITHOUT THE WRITTEN PERMISSION OF RACAL-DANA INSTRUMENTS INC. THIS DOCUMENT AND THE TECHNICAL DATA HEREON DISCLOSED ARE THE PROPERTY OF RACAL-DANA INSTRUMENTS INC. AND ARE TO BE USED ONLY FOR THE PURPOSES OF ENGINEERING EVALUATION AND FOR INCORPORATION INTO TECHNICAL SPECIFICATIONS AND OTHER DOCUMENTS WHICH SPECIFY PROCUREMENT OF PRODUCTS FROM RACAL-DANA INSTRUMENTS INC.

RACAL-DANA Instruments Inc.
4 GOODYEAR, IRVINE, CALIFORNIA 92714

DOCUMENT TITLE

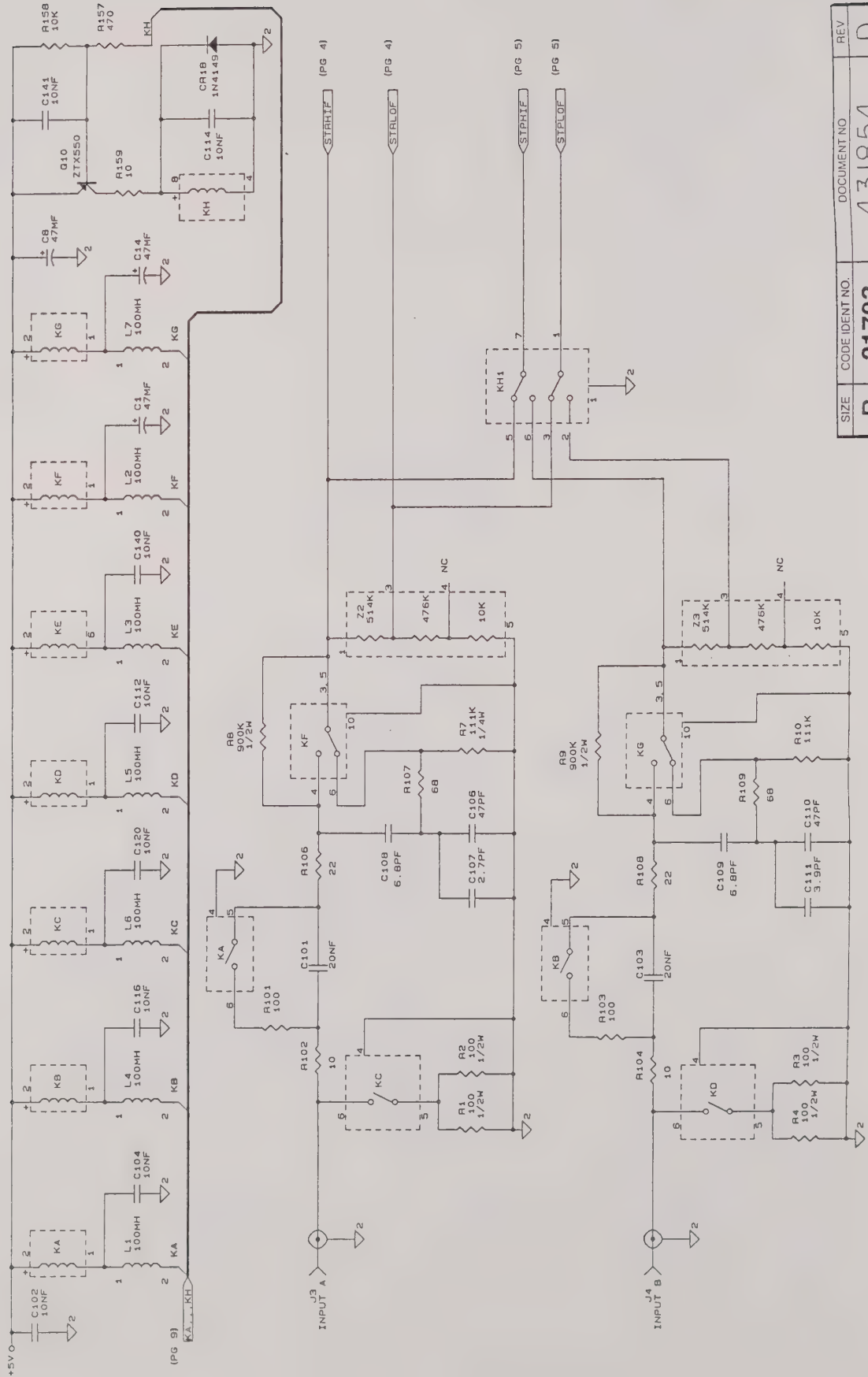
SCHEM., VME, 1993, COUNTER

SIZE	CODE IDENT NO	DOCUMENT NO	REV
B	21793	431854	D

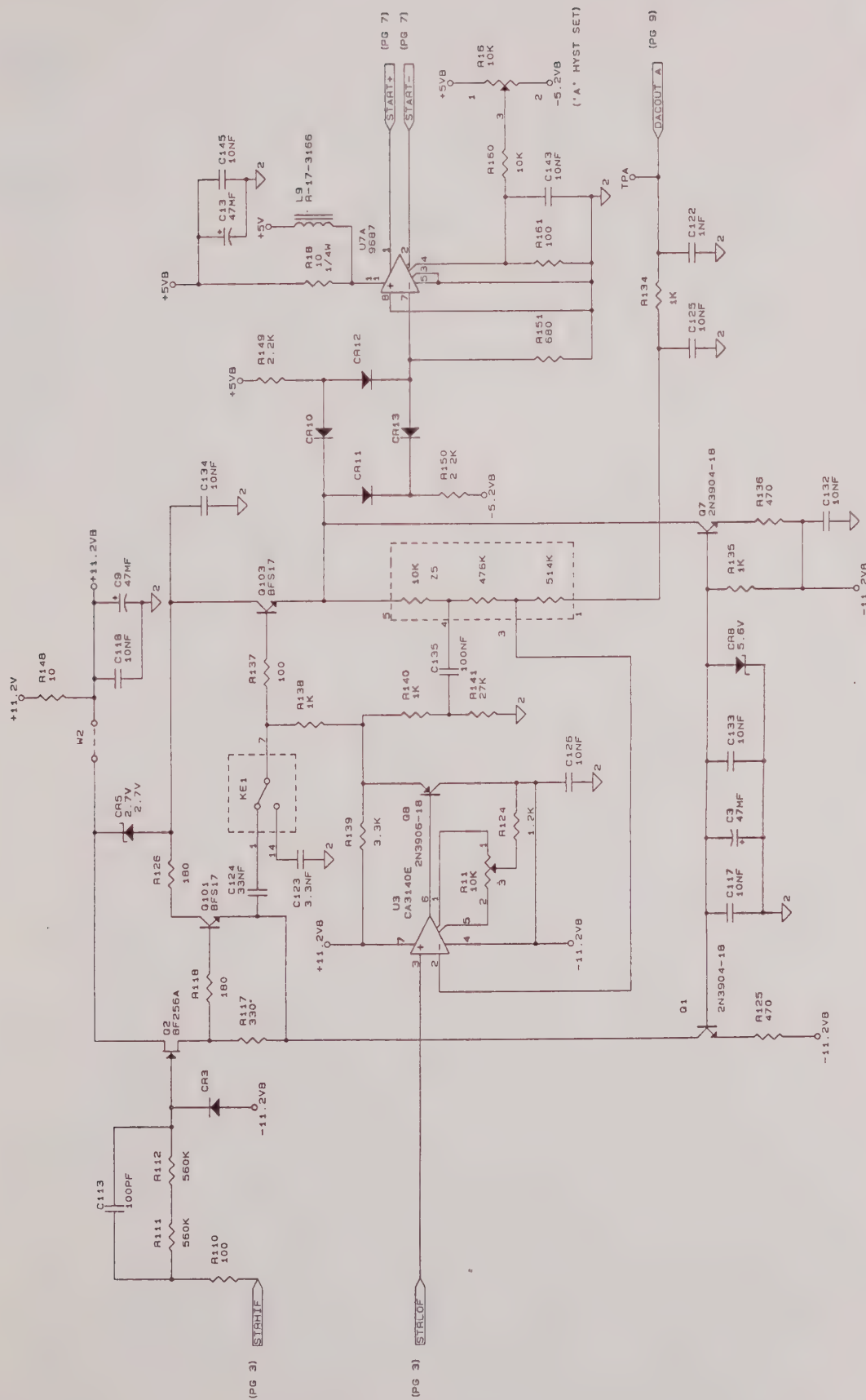
SCALE	NONE	SHEET	I	OF	13
-------	------	-------	---	----	----

5. RESISTOR NETWORKS ARE +/- 2%.
4. RESISTOR VALUES ARE IN OHMS, +/- 5%, 1/BW.
3. CAPACITOR VALUES ARE IN MICROFARADS, +/- 10%, 100V.
2. THIS +5V IS CONNECTED TO ALL IC'S UNLESS OTHERWISE SPECIFIED
1. THIS +5V IS CONNECTED TO IC'S U44, 45, 46, 50, 51, 52, 53, 54, 55, 56.

NOTES: UNLESS OTHERWISE SPECIFIED



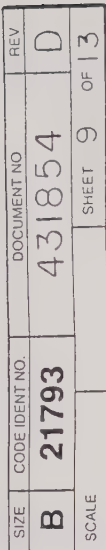
SIZE	CODE IDENT NO.	DOCUMENT NO.	REV
B	21793	431854	D
SCALE		SHEET 3	OF 13



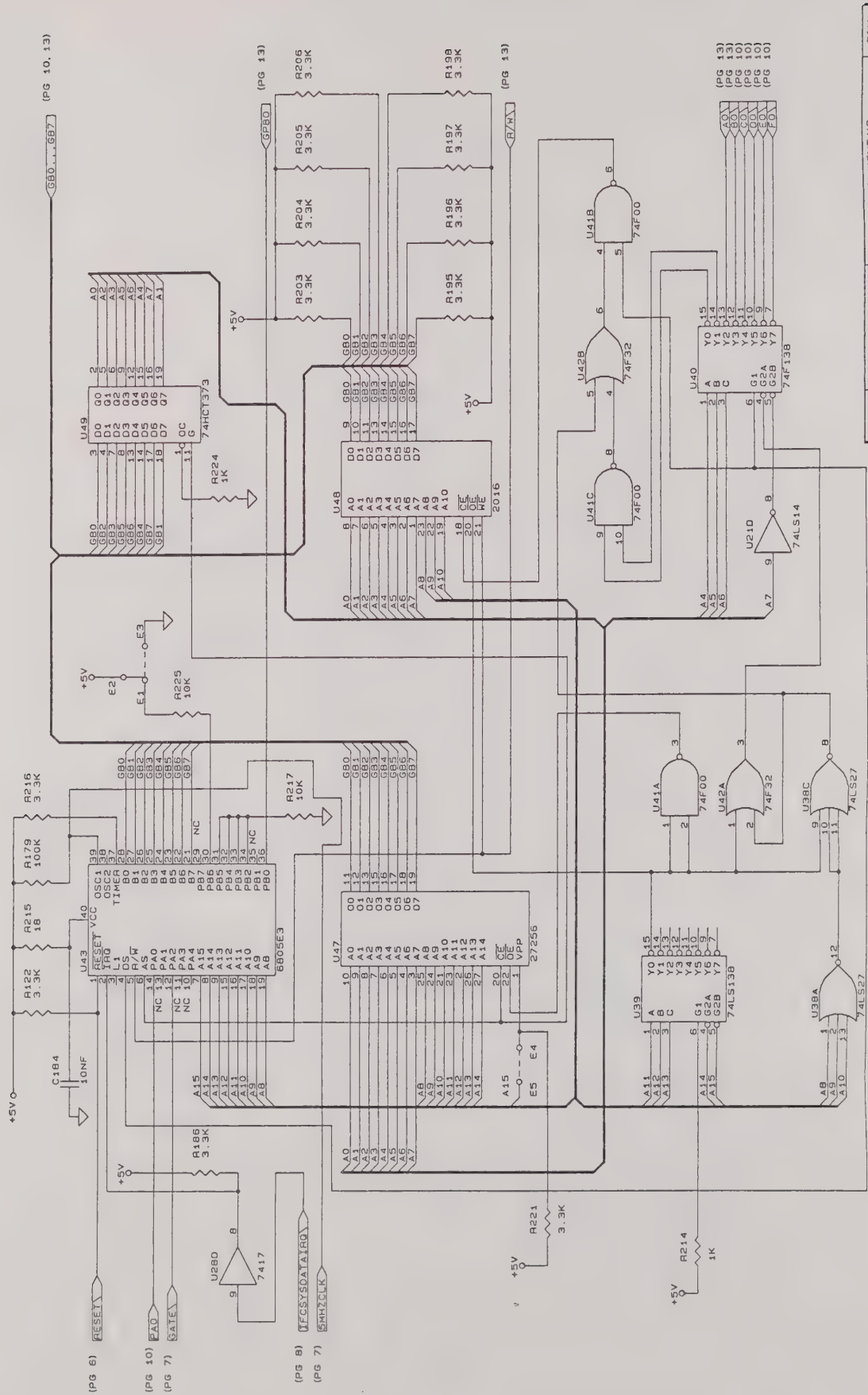
SIZE	CODE IDENT NO.	DOCUMENT NO.	REV
B	21793	431854	D
SCALE		SHEET 4	OF 13

SIZE	CODE IDENT NO	DOCUMENT NO	REV
B	21793	431854	D

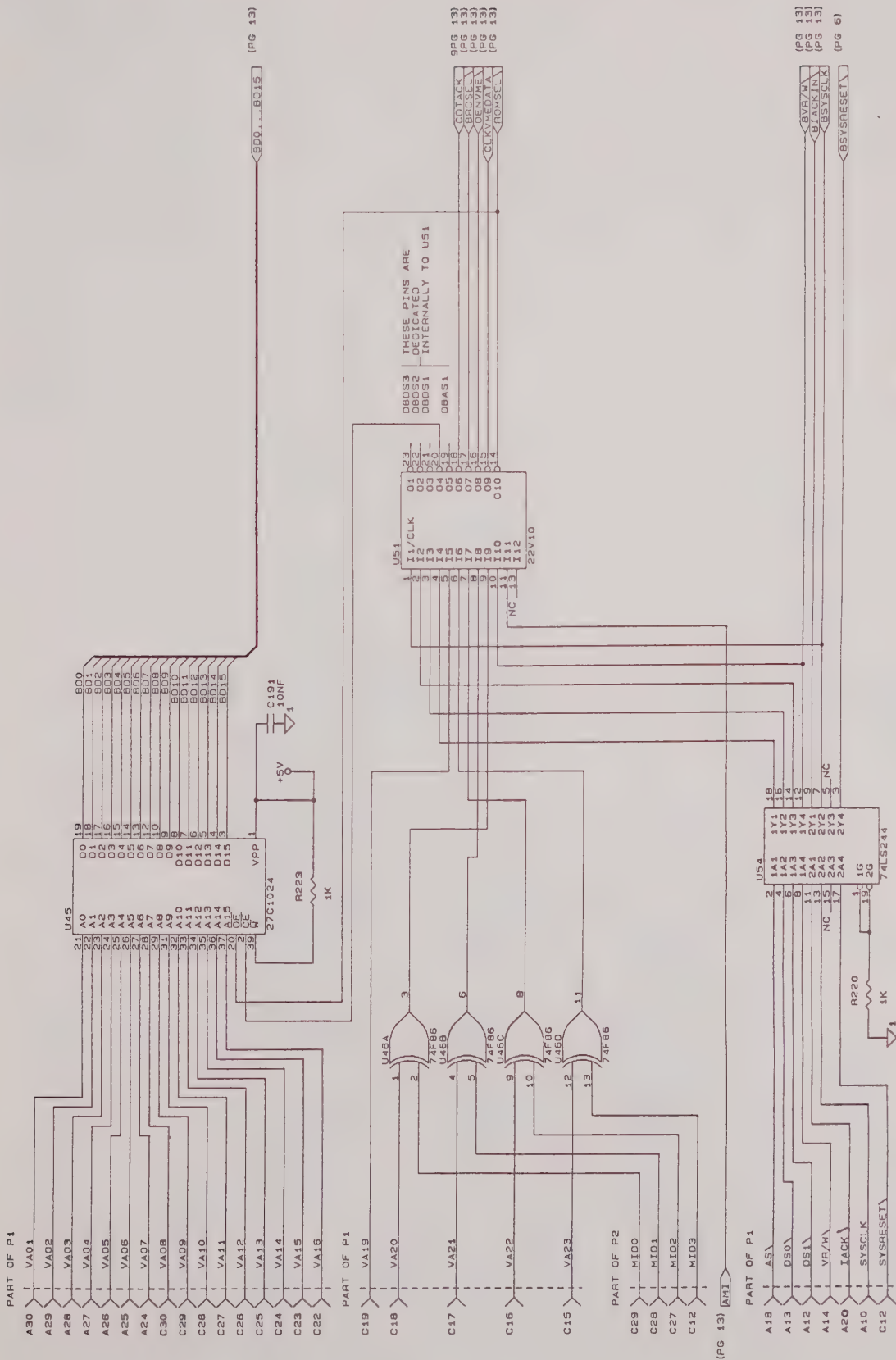
SCALE SHEET 7 OF 13



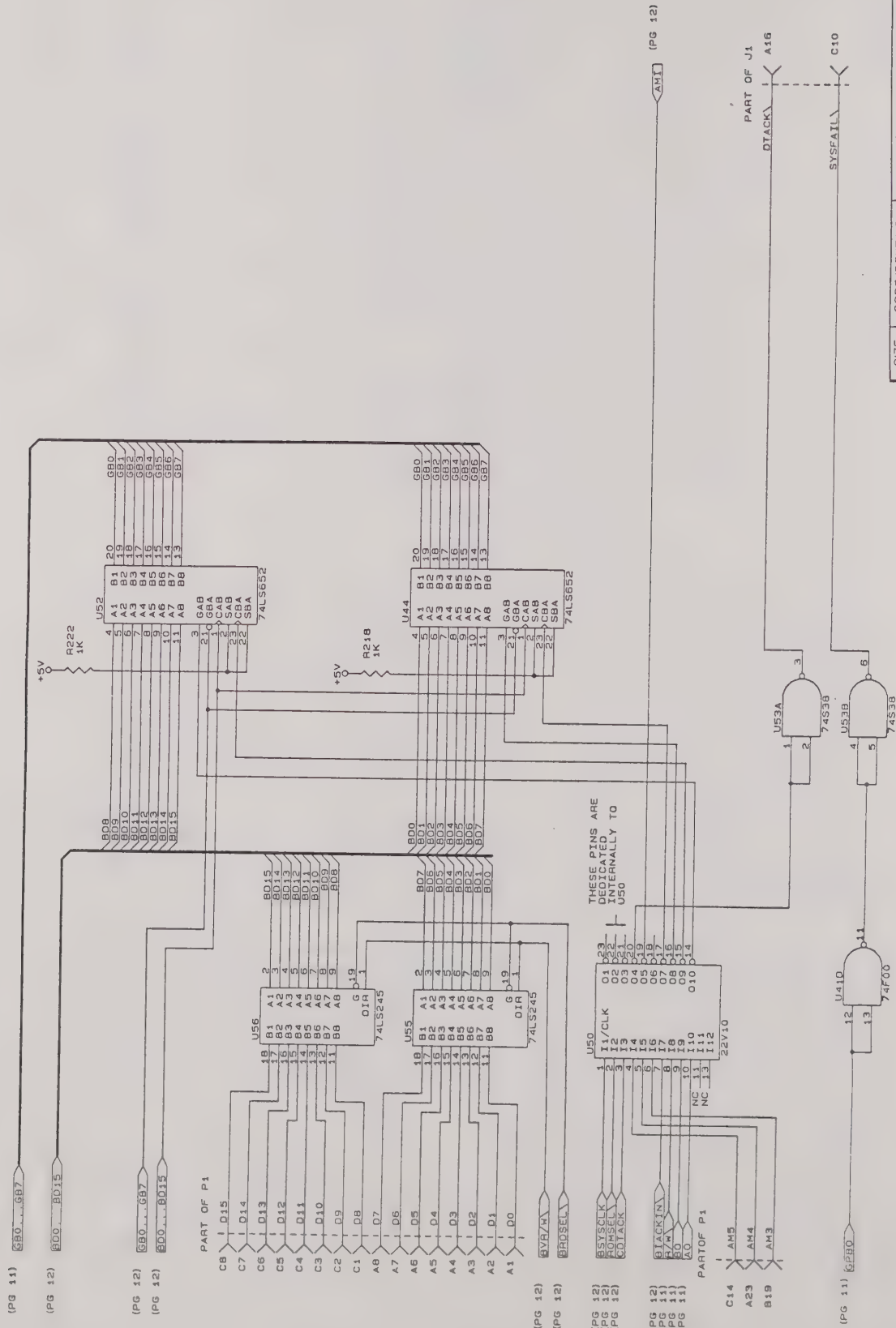




SIZE	CODE IDENT NO.	DOCUMENT NO.	REV.
B	21793	431854	D
SCALE	SHEET 11	OF 13	



SIZE	CODE IDENT NO	DOCUMENT NO	REV
B	21793	431854	D
SCALE		SHEET 12 OF 13	



SIZE	CODE IDENT NO.	DOCUMENT NO.	REV
B	21793	431854	D
SCALE		SHEET 13 OF 13	

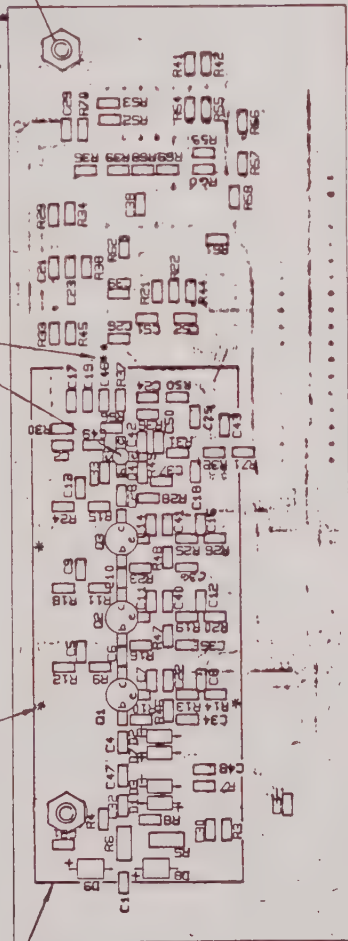
SEE DETAIL A
FOR INSTALLATION OF Q4

TRACKSIDE VIEW

SEE NOTE 2

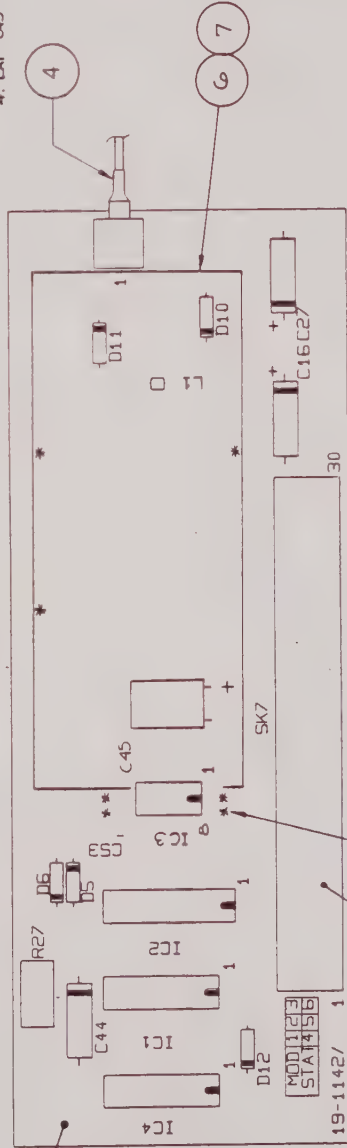
8 156 158
2 2 2

5 6



COMPONENT VIEW

10



CUT LEADS
AS SHORT
AS POSSIBLE,
4 PLCS

Q4

NOTE DIAGONAL CUT
FOR IDENTIFICATION
OF COLLECTOR LEAD

DETAIL A, TRACK SIDE
NO SCALE

1 SEE ZONE AC

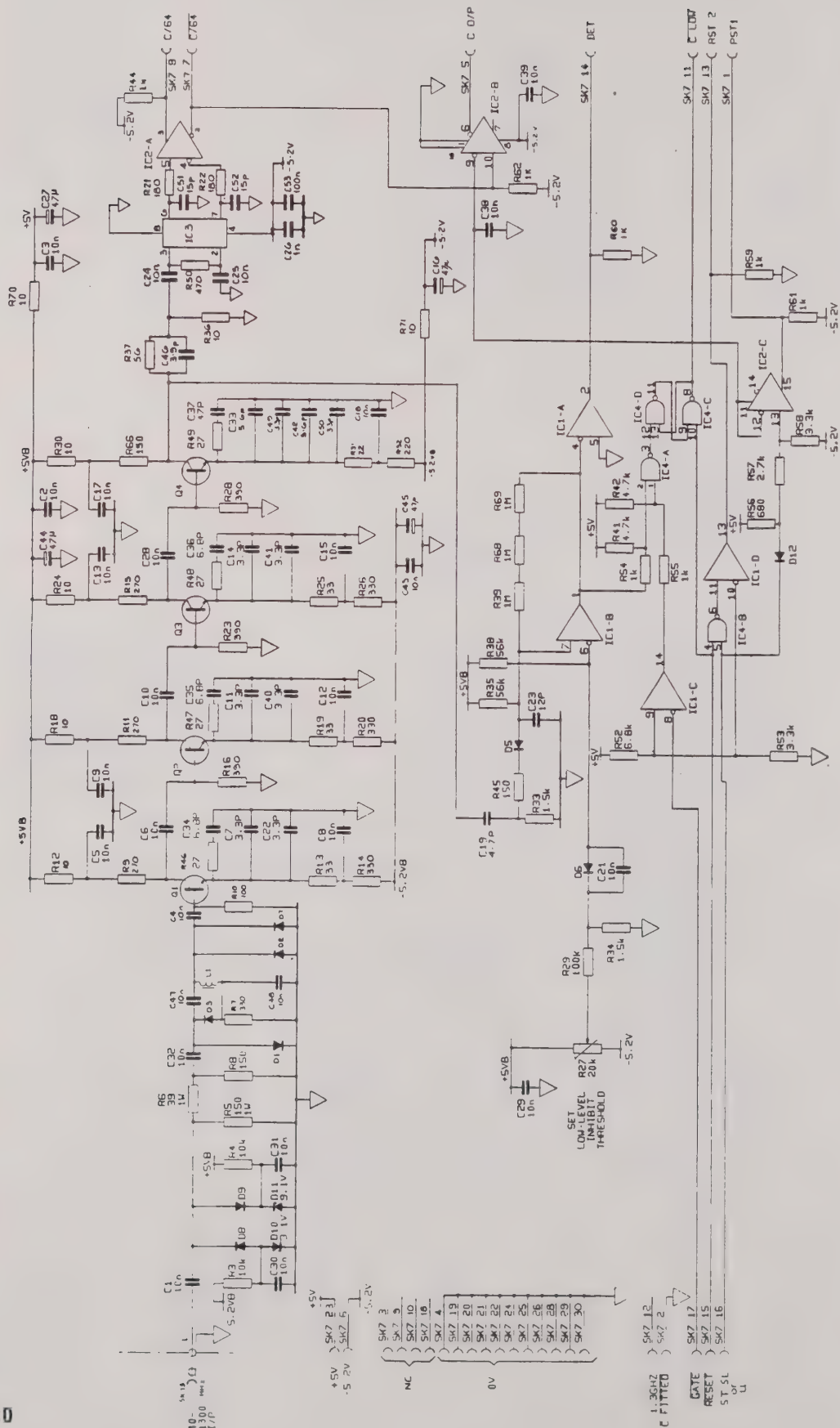
NOTES AND/OR DIMENSIONS SPECIFIED

NOTES

1. FIT ITEM 8 2 OFF TO PROTRUDE ON TRACKSIDE
2. FIT WIRE ITEM 166 TO PROTRUDE ON TRACKSIDE AND COMPANISE AND SOLDER TO ITEMS 5 AND 7 IN 6 POSNS MARKED THUS *
3. SOLDER SCREEN ITEM 6 TO COMPANISE IN 2 POSNS & TRACKSIDE 1 POSN MARKED THUS *
4. LAY C45 FLAT ON COMPANISE

THIS DOCUMENT AND THE TECHNICAL DATA HEREIN ARE UNCLASSIFIED AND ARE NOT TO BE RELEASED OR DISSEMINATED TO THE PUBLIC WITHOUT THE WRITTEN PERMISSION OF RACAL-DANA INSTRUMENTS INC. THIS DOCUMENT IS THE PROPERTY OF RACAL-DANA INSTRUMENTS INC. AND IS TO BE RETURNED TO THE COMPANY WHEN REQUESTED. IT IS NOT TO BE REPRODUCED OR TRANSMITTED IN ANY FORM OR BY ANY MEANS, ELECTRONIC OR MECHANICAL, INCLUDING PHOTOCOPYING, RECORDING, OR BY ANY INFORMATION STORAGE AND RETRIEVAL SYSTEM. RACAL-DANA INSTRUMENTS INC. 1968

RACAL-DANA Instruments Inc.	
A GOOD YEAR IRVINE CALIFORNIA 92714	
DOCUMENT TITLE	
PCB ASSY, CH C, 1953	
SIZE	CODE IDENT NO
D	21793
SCALE	1 OF 6



RACAL-DANA Instruments Inc.
IRVINE, CALIFORNIA

SCHEMATIC, CH. C

SIZE	CODE IDENT NO	QWQ NO	REV
D	21793	R-19-1142	C

SECTION 8

PARTS LIST

8.1 This section contains lists of replaceable parts arranged in the order of the following subassemblies.

404585	Module Assembly, 1993	8-4
404608	Module Assembly, 1993/41.....	8-5
401854	VME PCB Assembly	8-6
404626	Channel C PCB Assembly	8-11

8.2 Manufacturers are identified by FSC numbers listed in Table 8.1, "List of Suppliers." The code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1, H4-2, and their supplements.

Table 8.1 - List of Suppliers

FSC	NAME	FSC	NAME
00779	AMP, INC. HARRISBURG, PA	18714	RCA (COMMERCIAL REC. TUBE & SEMI. DIV.) FINDLAY, OH
01121	ALLEN BRADLEY CO. MILWAUKEE, WISCONSIN	19738	AVDEL-CHOBERT TELESBORO, NJ
01295	TEXAS INSTRUMENTS, INC. DALLAS, TEXAS	1CJ86	BOSSARD BROOKFIELD, CT
02114	FERROXCUBE CORP. SAUGERTIES, N.Y	21793	RACAL-DANA INSTRUMENTS INC. IRVINE, CA
02560	AMPHENOL CORP. BROADVIEW, ILLINOIS	22119	FERRANTI ELECTRIC PLAINVIEW, NY
04713	MOTOROLA, INC. (SEMI-CONDUCTOR PRODUCTS DIV.) PHOENIX, ARIZONA	22958	TELEDYNE ELECTRO MECHANISMS NASHUA, NH
05397	UNION CARBIDE CORP. (MATERIALS SYSTEMS DIV.) CLEVELAND, OHIO	24335	COOPER LABORATORIES, INC. WAYNE, NJ
06915	RICHCO PLASTIC CO. CHICAGO, ILLINOIS	24931	SPECIALTY CONNECTOR CO., INC. FRANKLIN, IN
07263	FAIRCHILD (SEMICONDUCTOR DIV.) MOUNTAIN VIEW, CA	24972	AEG-TELEFUNKEN CORP. SUMMERVILLE, NJ
11237	CTS KEENE, INC. PASO ROBLES, CA	25088	SIEMENS CORP. (COMP. GROUP) ISELIN, NJ
13764	MICRO PLASTICS INC. FLIPPIN, AR	25403	AMPEREX ELECTRONIC CORP. (SEMICONDUCTOR & REC. TUBE DIV.) SLATERSVILLE, RHODE ISLAND
14433	ITT SEMICONDUCTORS WEST PALM BEACH, FLORIDA	27014	NATIONAL SEMI-CONDUCTOR CORP. SANTA CLARA, CA
14936	GENERAL INSTRUMENTS CORP. (SEMICONDUCTOR PRODUCTS GROUP) HICKSVILLE, L.I., N.Y.	27264	MOLEX PRODUCTS CO. DOWNERS GROVE, ILLINOIS
16955	DENNISON MFG. CO. FRAMINGTON, MA	27777	VARO ELECTRONIC DEVICES, INC. GARLAND, TX
17856	SILICONIX, INC. SANTA CLARA, CA	28848	MULLARD, INC. FARMINGDALE, L.I., N.Y.
18324	SIGNETICS CORP. SUNNYVALE, CA	29005	STORM PRODUCTS CO. LOS ANGELES, CA
18565	CHOMERICS, INC. WOBURN, MA	2V900	BULGIN A.F. AND CO., LTD. BARKING ESSEX, ENGLAND
		32293	INTERSIL, INC. CUPERTINO, CA

Table 8.1 - List of Suppliers continued

FSC	NAME	FSC	NAME
32897	MURATA ERIE NORTH AMERICA INC. CARLISLE, PA	75915	LITTELFUSE, INC. DES PLAINES, IL
46384	PENN ENG. & MFG. CORP. DOYLESTOWN, PA	78189	ILLINOIS TOOL WORKS, INC. (SHAKEPROOF DIV.) ELGIN, IL
50434	HEWLETT-PACKARD CO. (HPA DIV.) PALO ALTO, CA	78553	EATON CORP. (TINNERMAN PRODUCTS, INC.) CLEVELAND, OH
52072	CIRCUIT ASSY. CORP. COSTA MESA, CA	80031	MEPCO-ELECTRA MORRISTOWN, NJ
52210	KASON CORP. NEWARK, NJ	81349	MILITARY SPECIFICATION
52648	PLESSEY MEMORIES SANTA ANA, CA	82219	PHILIPS ECG INC. DIV. OF NORTH AMERICAN PHILIPS CORP. EMPORIUM, PA
53387	THREE (3)M CO. (ELECTRONIC PRODUCTS DIV.) ST. PAUL, MN	83125	NYTRONICS, INC. DARLINGTON, SC
56235	STATE OF THE ART INC. STATE COLLEGE, PA	83330	HERMAN H. SMITH, INC. BROOKLYN, NY
51058	MATSUSHITA ELECTRIC CORP. OF AMERICA PANASONIC INDUSTRIAL CO. DIV. SECAUCUS, NJ	88044	AERONAUTICAL STANDARDS GROUP DEPT. OF NAVY AND AIR FORCE
61802	TOSHIBA INTERNATIONAL HOUSTON, TX	8C945	ELECTRONIZED CHEMICAL CO. BALTIMORE, MD
61935	SCHURTER, INC. PETALUMA, CA	91506	AUGAT, INC. ATTLEBORO, MA
63878	AP PRODUCTS, INC. MENTOR, OH	91637	DALE ELECTRONICS, INC. COLUMBUS, NE
65238	NOVACAP BURBANK, CA	91718	GENTECH AN INDIAN HEAD CO. LINDEN, NJ
65940	ROHM CORP. IRVINE, CA	95275	VITRAMON, INC. BRIDGEPORT, CN
70903	BELDEN CORP. CHICAGO, IL	96906	MILITARY SPECIFICATION
71400	BUSSMAN MFG. (DIV. MCGRAW & EDISON CO.) ST. LOUIS, MO	K0536	HARWIN ENGINEERS HANTS, ENGLAND
71450	CTS CORP. ELKHART, IN	K1160	WELWNY MICROELECTRONICS NORTHUMBERLAND, ENGLAND
72982	ERIE TECHNOLOGICAL PRODUCTS, INC. ERIE, PA	K1935	JERMYN MANUFACTURING KENT, ENGLAND
		K2324	WEBB FASTENERS BERKSHIRE, ENGLAND
		U3065	TOKO BERKSHIRE, ENGLAND
		U3441	QUADRANT METER CO., LTD. HERTS, ENGLAND

404585 - MODULE ASSY., 1993

REF DESIG	RACAL-DANA P/N	DESCRIPTION	FSC	MANUFACTURER'S P/N
{1}1	401854	PCB ASSY., VME, 1993	21793	401854
{4}1	455235	PLATE, FACE	21793	455224
{5}1	455236	HOUSING, PCB	21793	455236
{8}1	610231	BUTTON, PLUG, PLASTIC, NYLON, BLACK	28520	2643(DP-500)
{9}1	611184	STANDOFF, SNAP-IN, SCREW	06540	1935N
{10}2	611186	SCREW, PHILLIPS FILLISTER, 4-24 X .500	23338	2800-39-4208
{11}6	611187	SCREW, PPH, 4-24 X .500	23338	2800-22-4108
{12}2	611188	FASTENER, SPLIT, NYLON	23338	2800-09-0044
{15}4	615541	SCREW, PFH, 4-40X.250	-	-
{16}1	920888	LABEL, IDENTIFICATION	21793	920888
{17}1	921095	END CAP, REAR	23338	1400-02-2050
{18}1	921096	END CAP, FORWARD	23338	1400-02-2633
{19}1	921098	COVER, HOUSING	23338	1400-02-2943

404608 - MODULE ASSY., 1993/41

REF DESIG	RACAL-DANA P/N	DESCRIPTION	FSC	MANUFACTURER'S P/N
{1}1	401854	PCB ASSY., VME, 1993	21793	401854
{2}1	404626	PCB ASSY., CHANNEL C, 1993	21793	404626
{5}1	455235	PLATE, FACE	21793	455224
{6}1	455236	HOUSING, PCB	21793	455236
{7}1	455238	PLATE, NUT, BNC	21793	455238
{9}1	601235	CONNECTOR, BNC, PANEL MOUNT, FUSED	21793	601235
{11}2	611066	SCREW, PPH, M3 X 6 MM	---	---
{13}1	611184	STANDOFF, SNAP-IN, SCREW	06540	1935N
{14}2	611186	SCREW, PHILLIPS FILLISTER, 4-24 X .500	23338	2800-39-4208
{15}6	611187	SCREW, PPH, 4-24 X .500	23338	2800-22-4108
{16}2	611188	FASTENER, SPLIT, NYLON	23338	2800-09-0044
{18}4	615541	SCREW, PFH, 4-40X.250	-	-
{19}2	617102	WASHER, FLAT, #4, LIGHT SERIES	-	-
{20}2	617127	WASHER, LOCK, #4, LIGHT SERIES	-	-
{21}1	920888	LABEL, IDENTIFICATION	21793	920888
{22}1	921095	END CAP, REAR	23338	1400-02-2050
{23}1	921096	END CAP, FORWARD	23338	1400-02-2633
{24}1	921098	COVER, HOUSING	23338	1400-02-2943

401854 - PCB ASSY., 1993 COUNTER

REF DESIG	RACAL-DANA P/N	DESCRIPTION	FSC	MANUFACTURER'S P/N
C1	R-21-0789	CAP, ALUM. ELEC, 47 UF, 25V	61058	ECEA1EV470S
C2	110215	CAP, TANTA, 1.5 UF, 25V, 1 PERCENT	80031	1GS155A025KA1
C3	R-21-0789	CAP, ALUM. ELEC, 47 UF, 25V	61058	ECEA1EV470S
C4	100133	CAP, CERAM, .1 UF, LOW PROFILE, 20 PERCENT	32897	8131LP-100-25U-104M
C5-17	R-21-0789	CAP, ALUM. ELEC, 47 UF, 25V	61058	ECEA1EV470S
C18-19	110162	CAP, TANTA, .33 UF, 35V, 10 PERCENT	05397	T368A334J035AS
C20	100133	CAP, CERAM, .1 UF, LOW PROFILE, 20 PERCENT	32897	8131LP-100-25U-104M
C21	110126	CAP, TANTA, 6.8UF, 35V, 20 PERCENT	05397	T355F685M035A5
C22	100133	CAP, CERAM, .1 UF, LOW PROFILE, 20 PERCENT	32897	8131LP-100-25U-104M
C23-24	110126	CAP, TANTA, 6.8UF, 35V, 20 PERCENT	05397	T355F685M035A5
C25	100133	CAP, CERAM, .1 UF, LOW PROFILE, 20 PERCENT	32897	8131LP-100-25U-104M
C26	110126	CAP, TANTA, 6.8UF, 35V, 20 PERCENT	05397	T355F685M035A5
C27	100133	CAP, CERAM, .1 UF, LOW PROFILE, 20 PERCENT	32897	8131LP-100-25U-104M
C28	100133	CAP, CERAM, .1 UF, LOW PROFILE, 20 PERCENT	32897	8131LP-100-25U-104M
C29-30	110126	CAP, TANTA, 6.8UF, 35V, 20 PERCENT	05397	T355F685M035A5
C31	100133	CAP, CERAM, .1 UF, LOW PROFILE, 20 PERCENT	32897	8131LP-100-25U-104M
C32	110126	CAP, TANTA, 6.8UF, 35V, 20 PERCENT	05397	T355F685M035A5
C101	R-21-1847	CAP, CHIP, 20 NF, 400V	65238	12068203K401N
C102	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C103	R-21-1847	CAP, CHIP, 20 NF, 400V	65238	12068203K401N
C104-105	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C106	R-21-1862	CAP, CHIP, 47 PF, 2 PCT	95275	NJ1206A470GXA
C107	R-21-1780	CAP, CHIP, 2.7 PF	95275	VJ1206A2R7CF
C108-109	R-21-1859	CAP, CHIP, 6.8 PF, 400V	95275	VJ1206A6RBCX7400
C110	R-21-1862	CAP, CHIP, 47 PF, 2 PCT	95275	NJ1206A470GXA
C111	R-21-1782	CAP, CHIP, 3.9 PF	95275	VJ1206A3R9CF
C112	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C113	R-21-1857	CAP, CHIP, 100 PF, 400V	65238	1206N101K401N
C114	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C115	R-21-1857	CAP, CHIP, 100 PF, 400V	65238	1206N101K401N
C116-121	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C122	R-21-1800	CAP, CHIP, 1 NF	95275	VJ1206Y102KF
C123	R-21-1858	CAP, CHIP, 3.3 NF, 50V	95275	VJ1026Y332KF
C124	R-21-1808	CAP, CHIP, 33 NF	95275	VJ1206Y333KF
C125-127	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C128	R-21-1808	CAP, CHIP, 33 NF	95275	VJ1206Y333KF
C129	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C130-131	R-21-1800	CAP, CHIP, 1 NF	95275	VJ1206Y102KF
C132-134	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C135	R-21-1802	CAP, CHIP, 100 NF	95275	VJ1206Y104MF
C136-147	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C148	R-21-1802	CAP, CHIP, 100 NF	95275	VJ1206Y104MF
C149-153	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C154-155	R-21-1802	CAP, CHIP, 100 NF	95275	VJ1206Y104MF
C156-162	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C163	R-21-1802	CAP, CHIP, 100 NF	95275	VJ1206Y104MF
C164-197	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
CR1	R-22-1029	DIODE, SILICON	14433	1N4149
CR2	230551	IC, VOLTAGE REFERENCE	24355	AD589JH
CR3-4	R-22-1099	DIODE, SILICON	17856	JPA050
CR5-6	R-22-1801	DIODE, VOLTAGE REGULATOR, 2.7V, 400 MW	14433	ZPD2.7
CR7	211083	DIODE, SILICON	81349	1N9168
CR8-9	R-22-1809	DIODE, VOLTAGE REGULATOR, 5.6V, 400 MW	14433	ZF.5.6A
CR10-17	210089	DIODE, LOW OFFSET SCHOTTKY	50434	HP5082-2835
CR18-20	R-22-1029	DIODE, SILICON	14433	1N4149
J3-5	601677	CONNECTOR, COAX, PLUG, PCB	91836	KC-79-237M06
KA	R-23-7529	RELAY, REED, 1A	91718	G57DX424
KB	R-23-7529	RELAY, REED, 1A	91718	G57DX424

401854 - PCB ASSY., 1993 COUNTER continued

REF DESIG	RACAL-DANA P/N	DESCRIPTION	FSC	MANUFACTURER'S P/N
KC	R-23-7529	RELAY, REED, 1A	91718	G57DX424
KD	R-23-7529	RELAY, REED, 1A	91718	G57DX424
KE	R-23-7530	RELAY, DIL, 1 FORM C	91718	GT831C-238
KF	R-23-7528	RELAY, REED, 1A1B	21793	R-23-7528
KG	R-23-7528	RELAY, REED, 1A1B	21793	R-23-7528
KH	R-23-7527	RELAY, DPDT	22958	172-5
L1-7	310151	CHOKE, 100 UH, 10 PERCENT	83125	DD100UH
L8-9	R-17-3166	CHOKE	21793	R-17-3166
L10-13	R-23-7193	RF CHOKE, 1.2 UH, 10 PERCENT	21793	R-23-7193
P1-2	601675	CONNECTOR, EUROCARD TYPE C, 96-PIN	00779	532505-1
PL1	601838-030	CONNECTOR, RT. ANGLE, 30-PIN	21793	601838-030
Q1	200298	TRANSISTOR, NPN	04713	2N3904
Q2-3	R-22-6163	TRANSISTOR, N-CH SILICON JFET	28848	BF256A
Q4	200299	TRANSISTOR, PNP	04713	2N3906
Q5	200298	TRANSISTOR, NPN	04713	2N3904
Q6	200295	TRANSISTOR, N-CHAN, MOSFET	17856	VN10KM
Q7	200298	TRANSISTOR, NPN	04713	2N3904
Q8	200299	TRANSISTOR, PNP	04713	2N3906
Q9	200298	TRANSISTOR, NPN	04713	2N3904
Q10	R-22-6113	TRANSISTOR, PNP	22119	ZTX550
Q101-104	R-22-6206	TRANSISTOR, RF, NPN	22119	BFS17
R1-4	001675	RES, CARB COMP, 100 OHM, 5 PERCENT, 1/2W	01121	RC20GF101J
R5	000221	RES, CARBON, 220 OHM, 1/4W, 5 PERCENT	81349	RC07GF221J
R6	012004	RES, METAL FILM, 1/8W, 1 PERCENT	81349	RN55C4121F
R7	010989	RES, METAL FILM, 111K, 0.1 PERCENT, 1/8W	80031	RN55C1113B
R8-9	010990	RES, METAL FILM, 900K, 0.1 PERCENT, 1/2W	80031	RN65C9003B
R10	010989	RES, METAL FILM, 111K, 0.1 PERCENT, 1/8W	80031	RN55C1113B
R11-12	R-20-7071	POT, 10K, TOP ADJ	21793	R-20-7071
R13	000225	RES, CARBON, 2.2M, 1/4W, 5 PERCENT	81349	RC07GF225J
R14	012004	RES, METAL FILM, 1/8W, 1 PERCENT	81349	RN55C4121F
R15	000474	RES, CARBON, 470K, 1/4W, 5 PERCENT	81349	RC07GF474J
R16	R-20-7071	POT, 10K, TOP ADJ	21793	R-20-7071
R17	000100	RES, CARB COMP, 10 OHM, 5 PERCENT, 1/4W	81349	RC07GF100J
R18	000100	RES, CARB COMP, 10 OHM, 5 PERCENT, 1/4W	81349	RC07GF100J
R19	R-20-7071	POT, 10K, TOP ADJ	21793	R-20-7071
R20	000391	RES, CARB COMP, 390 OHM, 5 PERCENT, 1/4W	81349	RC07GF391J
R21	000391	RES, CARB COMP, 390 OHM, 5 PERCENT, 1/4W	81349	RC07GF391J
R101	R-20-5764	RES, CHIP, 100 OHM, 1/8W, 5 PCT	65940	MCR18-100 OHM-5 PCT
R102	R-20-5771	RES, CHIP, 10 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-10 OHM-5 PCT
R103	R-20-5764	RES, CHIP, 100 OHM, 1/8W, 5 PCT	65940	MCR18-100 OHM-5 PCT
R104	R-20-5771	RES, CHIP, 10 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-10 OHM-5 PCT
R105	R-20-5799	RES, CHIP, 4.7K, 1/8W, 5 PCT, 200V	65940	MCR18-4.7K-5 PCT
R106	R-20-5774	RES, CHIP, 22 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-22 OHM-5 PCT
R107	R-20-5780	RES, CHIP, 68 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-68 OHM-5 PCT
R108	R-20-5774	RES, CHIP, 22 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-22 OHM-5 PCT
R109	R-20-5780	RES, CHIP, 68 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-68 OHM-5 PCT
R110	R-20-5764	RES, CHIP, 100 OHM, 1/8W, 5 PCT	65940	MCR18-100 OHM-5 PCT
R111-113	R-20-5817	RES, CHIP, 560K, 1/8W, 5 PCT, 200V	65940	MCR18-560K-5 PCT
R114	R-20-5764	RES, CHIP, 100 OHM, 1/8W, 5 PCT	65940	MCR18-100 OHM-5 PCT
R115	R-20-5817	RES, CHIP, 560K, 1/8W, 5 PCT, 200V	65940	MCR18-560K-5 PCT
R116	R-20-5770	RES, CHIP, 1M, 1/8W, 5 PCT	65940	1M OHM-5 PCT
R117	R-20-5787	RES, CHIP, 330 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-330 OHM-5 PCT
R118	R-20-5784	RES, CHIP, 180 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-180 OHM-5 PCT
R119	R-20-5787	RES, CHIP, 330 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-330 OHM-5 PCT
R120-121	R-20-5784	RES, CHIP, 180 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-180 OHM-5 PCT
R122	R-20-5797	RES, CHIP, 3.3K, 1/8W, 5 PCT, 200V	65940	MCR18-3.3K-5 PCT
R123	R-20-5770	RES, CHIP, 1M, 1/8W, 5 PCT	65940	1M OHM-5 PCT
R124	R-20-5793	RES, CHIP, 1.2K, 1/8W, 5 PCT, 200V	65940	MCR18-1.2K-5 PCT

401854 - PCB ASSY., 1993 COUNTER continued

REF DESIG	RACAL-DANA P/N	DESCRIPTION	FSC	MANUFACTURER'S P/N
R125	R-20-5765	RES, CHIP, 470 OHM, 1/8W, 5 PCT	65940	MCR18-470 OHM-5 PCT
R126	R-20-5784	RES, CHIP, 180 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-180 OHM-5 PCT
R127	R-20-5765	RES, CHIP, 470 OHM, 1/8W, 5 PCT	65940	MCR18-470 OHM-5 PCT
R128	R-20-5792	RES, CHIP, 1K, 1/8W, 5 PCT, 200V	65940	MCR18-1K-5 PCT
R129	R-20-5793	RES, CHIP, 1.2K, 1/8W, 5 PCT, 200V	65940	MCR18-1.2K-5 PCT
R130	R-20-5770	RES, CHIP, 1M, 1/8W, 5 PCT	65940	1M OHM-5 PCT
R131-132	R-20-5813	RES, CHIP, 100K, 1/8W, 5 PCT, 200V	65940	MCR18-100K-5 PCT
R133-135	R-20-5792	RES, CHIP, 1K, 1/8W, 5 PCT, 200V	65940	MCR18-1K-5 PCT
R136	R-20-5765	RES, CHIP, 470 OHM, 1/8W, 5 PCT	65940	MCR18-470 OHM-5 PCT
R137	R-20-5764	RES, CHIP, 100 OHM, 1/8W, 5 PCT	65940	MCR18-100 OHM-5 PCT
R138	R-20-5792	RES, CHIP, 1K, 1/8W, 5 PCT, 200V	65940	MCR18-1K-5 PCT
R139	R-20-5797	RES, CHIP, 3.3K, 1/8W, 5 PCT, 200V	65940	MCR18-3.3K-5 PCT
R140	R-20-5792	RES, CHIP, 1K, 1/8W, 5 PCT, 200V	65940	MCR18-1K-5 PCT
R141	R-20-5806	RES, CHIP, 27K, 1/8W, 5 PCT, 200V	65940	MCR18-27K-5 PCT
R142	R-20-5792	RES, CHIP, 1K, 1/8W, 5 PCT, 200V	65940	MCR18-1K-5 PCT
R143	R-20-5806	RES, CHIP, 27K, 1/8W, 5 PCT, 200V	65940	MCR18-27K-5 PCT
R144	R-20-5765	RES, CHIP, 470 OHM, 1/8W, 5 PCT	65940	MCR18-470 OHM-5 PCT
R145	R-20-5792	RES, CHIP, 1K, 1/8W, 5 PCT, 200V	65940	MCR18-1K-5 PCT
R146	R-20-5764	RES, CHIP, 100 OHM, 1/8W, 5 PCT	65940	MCR18-100 OHM-5 PCT
R147	R-20-5797	RES, CHIP, 3.3K, 1/8W, 5 PCT, 200V	65940	MCR18-3.3K-5 PCT
R148	R-20-5771	RES, CHIP, 10 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-10 OHM-5 PCT
R149	R-20-5796	RES, CHIP, 2.2K, 1/8W, 5 PCT, 200V	65940	MCR18-2.2K-5 PCT
R150	R-20-5796	RES, CHIP, 2.2K, 1/8W, 5 PCT, 200V	65940	MCR18-2.2K-5 PCT
R151-152	R-20-5790	RES, CHIP, 680 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-680 OHM-5 PCT
R153	R-20-5796	RES, CHIP, 2.2K, 1/8W, 5 PCT, 200V	65940	MCR18-2.2K-5 PCT
R154	R-20-5796	RES, CHIP, 2.2K, 1/8W, 5 PCT, 200V	65940	MCR18-2.2K-5 PCT
R155	R-20-5771	RES, CHIP, 10 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-10 OHM-5 PCT
R156	R-20-5813	RES, CHIP, 100K, 1/8W, 5 PCT, 200V	65940	MCR18-100K-5 PCT
R157	R-20-5765	RES, CHIP, 470 OHM, 1/8W, 5 PCT	65940	MCR18-470 OHM-5 PCT
R158	R-20-5768	RES, CHIP, 10K, 1/8W, 5 PCT	65940	MCR18-10K OHM-5 PCT
R159	R-20-5771	RES, CHIP, 10 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-10 OHM-5 PCT
R160	R-20-5768	RES, CHIP, 10K, 1/8W, 5 PCT	65940	MCR18-10K OHM-5 PCT
R161-162	R-20-5764	RES, CHIP, 100 OHM, 1/8W, 5 PCT	65940	MCR18-100 OHM-5 PCT
R163	R-20-5768	RES, CHIP, 10K, 1/8W, 5 PCT	65940	MCR18-10K OHM-5 PCT
R164	R-20-5771	RES, CHIP, 10 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-10 OHM-5 PCT
R165-170	R-20-5787	RES, CHIP, 330 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-330 OHM-5 PCT
R171	R-20-5792	RES, CHIP, 1K, 1/8W, 5 PCT, 200V	65940	MCR18-1K-5 PCT
R172	R-20-5771	RES, CHIP, 10 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-10 OHM-5 PCT
R173-177	R-20-5787	RES, CHIP, 330 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-330 OHM-5 PCT
R178	R-20-5780	RES, CHIP, 68 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-68 OHM-5 PCT
R179	R-20-5813	RES, CHIP, 100K, 1/8W, 5 PCT, 200V	65940	MCR18-100K-5 PCT
R180	R-20-5768	RES, CHIP, 10K, 1/8W, 5 PCT	65940	MCR18-10K OHM-5 PCT
R181	R-20-5792	RES, CHIP, 1K, 1/8W, 5 PCT, 200V	65940	MCR18-1K-5 PCT
R182-183	R-20-5768	RES, CHIP, 10K, 1/8W, 5 PCT	65940	MCR18-10K OHM-5 PCT
R184	R-20-5792	RES, CHIP, 1K, 1/8W, 5 PCT, 200V	65940	MCR18-1K-5 PCT
R185	R-20-5792	RES, CHIP, 1K, 1/8W, 5 PCT, 200V	65940	MCR18-1K-5 PCT
R186	R-20-5797	RES, CHIP, 3.3K, 1/8W, 5 PCT, 200V	65940	MCR18-3.3K-5 PCT
R187-194	R-20-5813	RES, CHIP, 100K, 1/8W, 5 PCT, 200V	65940	MCR18-100K-5 PCT
R195-199	R-20-5797	RES, CHIP, 3.3K, 1/8W, 5 PCT, 200V	65940	MCR18-3.3K-5 PCT
R200	R-20-5797	RES, CHIP, 3.3K, 1/8W, 5 PCT, 200V	65940	MCR18-3.3K-5 PCT
R201-202	R-20-5792	RES, CHIP, 1K, 1/8W, 5 PCT, 200V	65940	MCR18-1K-5 PCT
R203-210	R-20-5797	RES, CHIP, 3.3K, 1/8W, 5 PCT, 200V	65940	MCR18-3.3K-5 PCT
R211-213	R-20-5813	RES, CHIP, 100K, 1/8W, 5 PCT, 200V	65940	MCR18-100K-5 PCT
R214	R-20-5792	RES, CHIP, 1K, 1/8W, 5 PCT, 200V	65940	MCR18-1K-5 PCT
R215	R-20-5763	RES, CHIP, 18 OHM, 1/8W, 5 PCT	65940	MCR18-18 OHM-5 PCT
R216	R-20-5797	RES, CHIP, 3.3K, 1/8W, 5 PCT, 200V	65940	MCR18-3.3K-5 PCT
R217	R-20-5768	RES, CHIP, 10K, 1/8W, 5 PCT	65940	MCR18-10K OHM-5 PCT
R218	R-20-5792	RES, CHIP, 1K, 1/8W, 5 PCT, 200V	65940	MCR18-1K-5 PCT

401854 - PCB ASSY., 1993 COUNTER continued

REF DESIG	RACAL-DANA P/N	DESCRIPTION	FSC	MANUFACTURER'S P/N
R219	R-20-5766	RES, CHIP, 2.7K, 1/8W, 5 PCT	65940	MCR18-2.7K OHM-5 PCT
R220	R-20-5792	RES, CHIP, 1K, 1/8W, 5 PCT, 200V	65940	MCR18-1K-5 PCT
R221	R-20-5797	RES, CHIP, 3.3K, 1/8W, 5 PCT, 200V	65940	MCR18-3.3K-5 PCT
R222-224	R-20-5792	RES, CHIP, 1K, 1/8W, 5 PCT, 200V	65940	MCR18-1K-5 PCT
R225	R-20-5768	RES, CHIP, 10K, 1/8W, 5 PCT	65940	MCR18-10K OHM-5 PCT
R226	000103	RES, CARBON, 10K, 1/4W, 5 PERCENT	81349	RC07GF103J
U1	R-17-1035	HYBRID DAC	21793	R-17-1035
U2	230547	IC, QUAD COMPARATOR	27014	LM339N/A-1
U3-4	R-22-4269	IC, MOS/FET INPUT, BI POLAR OUTPUT OP-AMP	18714	CA3140E
U5	230368	IC, DEMULTIPLEXER	27014	SN74LS138N3
U6	231011	IC, EPROM	21793	231011
U7	230735	IC, COMPARATOR, DUAL ULTRA FAST	51870	AD9687BD
U8	230806	IC, OCTAL TRANSPARENT LATCH, 3-STATE OUTPUT	18714	CD74HCT373EX
U9	230193	IC, QUAD 2-INPUT NAND GATES	01295	SN74LS00N
U10	230791	IC, TIMING ERROR CORRECTION	21793	230791
U11	230789	IC, DIGITAL CUSTOM CHIP	21793	230789
U12	230733	IC, DIGITAL ECL FLIP-FLOP	04713	MC10231PDS
U13	230787	IC, DIGITAL TRIPLE LINE RECEIVER	04713	MC10116PDS
U14	230428	IC, QUAD 2-INPUT OR GATE	01295	SN74LS32N3
U15	230790	IC, DIGITAL CUSTOM CHIP	21793	230790
U16	230561-001	IC, OCTAL LATCH, SELECTED	21793	230561-001
U17	230821	IC, CPU, CMOS, 64K EXT MEMORY	18714	CD6805E33X
U18	230561-001	IC, OCTAL LATCH, SELECTED	21793	230561-001
U19	230234	IC, HEX INVERTER	01295	SN74LS04N
U20	R-22-4807	IC, OCTAL BUFFER/LINE DRIVER, 3-STATE	18714	CD74HCT244E
U21	230336	IC, HEX SCHMITT TRIGGER	01295	74LS14
U22	230803	IC, QUAD 2-INPUT EXCLUSIVE OR GATE	02735	74HCT86
U23	230805	IC, QUAD 2-INPUT NOR GATE	02735	74HCT02
U24	230201	IC, REGULATOR	07263	UA7912UCQR
U25	230200	IC, 12 VDC REGULATOR	04713	MC7812CT
U26	230796	IC, QUAD 2-INPUT NAND GATE	02735	74HCT00E
U27	230798	IC, QUAD D W/SET & RESET	18714	CD74HCT74EX
U28	230105	IC, HEX BUFFER/DRIVER	01295	SN7417N3
U29	230648	IC, MEMORY, 2KX8 RAM	61802	TMM2016P
U30	230802	IC, OCTAL D-TYPE F-F, 3-STATE	18714	CD74HCT374EX
U31	230802	IC, OCTAL D-TYPE F-F, 3-STATE	18714	CD74HCT374EX
U32	230798	IC, QUAD D W/SET & RESET	18714	CD74HCT74EX
U33-34	230802	IC, OCTAL D-TYPE F-F, 3-STATE	18714	CD74HCT374EX
U35	230798	IC, QUAD D W/SET & RESET	18714	CD74HCT74EX
U36	230710	IC, DIGITAL DECODER	07263	74F138
U37	230330	IC, NON-INV. HEX BUS DRIVER	01295	SN74LS367AN
U38	230716	IC, DIGITAL 3-INPUT NOR	01295	SN74LS27N3
U39	230368	IC, DEMULTIPLEXER	27014	SN74LS138N3
U40	230710	IC, DIGITAL DECODER	07263	74F138
U41	230719	IC, FAST NAND	07263	74F00
U42	230711	IC, QUAD 2-INPUT OR GATE	07263	74F32PC
U43	230821	IC, CPU, CMOS, 64K EXT MEMORY	18714	CD6805E33X
U44	230936	IC, OCTAL BUS TRNCVRS & REGISTRs	01295	SN74LS652NT
U45	231010	IC, EPROM	21793	231010
U46	230630	IC, EXCLUSIVE OR	07263	74F86PC
U47	231012	IC, EPROM	21793	231012
U48	230648	IC, MEMORY, 2KX8 RAM	61802	TMM2016P
U49	230806	IC, OCTAL TRANSPARENT LATCH, 3-STATE OUTPUT	18714	CD74HCT373EX
U50	231013	IC, PLA. 22V10	21793	231013
U51	231014	IC, PLA. 22V10	21793	231014
U52	230936	IC, OCTAL BUS TRNCVRS & REGISTRs	01295	SN74LS652NT
U53	230848	IC, QUAD NAND BUFFER O.C.	01295	SN74S38N
U54	230637	IC, DIGITAL BUFFER	18324	N74LS244
U55-56	230957	IC, OCTAL BUS TRNCVRS W/3-STATE OUTPUT	01295	74LS245N3

401854 - PCB ASSY., 1993 COUNTER continued

REF DESIG	RACAL-DANA P/N	DESCRIPTION	FSC	MANUFACTURER'S P/N
W1	600245	JUMPER, INSULATED	52210	L-2007-1
W2	600245	JUMPER, INSULATED	52210	L-2007-1
Z1	080005	RES NETWORK, 6P8R, 10K, 2 PERCENT, .9W	11236	750-61-R10K
Z2-3	R-20-5554	CUSTOM RES ARRAY, SIL	21793	R-20-5554
Z4	080005	RES NETWORK, 6P8R, 10K, 2 PERCENT, .9W	11236	750-61-R10K
Z5-6	R-20-5554	CUSTOM RES ARRAY, SIL	21793	R-20-5554
{110}1	411854	PCB, 1993 COUNTER	21793	411854
{113}A/R	500023	WIRE, BARE COPPER/TIN, 24 GA	21793	500023
{114}1	601195	PLUG, JUMPER, 0.1 CTR, LOW PROFILE	00779	530153-2
{116}2	601208-010	CONNECTOR, PCB, PLUG, 2-PIN	21793	601208-010
{118}1	601208-016	CONNECTOR, PCB, PLUG, 3-PIN	52072	CA-S03-23B-43
{120}2	601606	SOCKET, IC, 24-PIN, LOW PROFILE	00779	641933-4
{125}4	610288	STANDOFF, SWAGE, 4-40	06540	9532B-8-0440-3A
{126}2	610851	INSULATOR, TO-220	18565	60-11-5791-1674
{128}5	611059	CONNECTOR, DIP, LOW PROFILE, 40-PIN	91506	240-AG39D
{130}1	616315	SCREW, PPH, M3X6	1CJ86	7985-A-M3X6MM
{131}2	616316	SCREW, PPH, M3X8	1CJ86	7985-A-M2.5X14MM
{133}2	617042	NUT, HEX, M3	1CJ86	DIN934-M3
{135}2	920624	SOCKET, IC, 24-PIN	52072	CA-24STSD-BC
{137}2	920891	SOCKET, 28-PIN	52072	CA-285-TSD
{139}1	R-13-1988	SCREEN	21793	R-13-1988
{141}1	R-13-2024	LID	21793	R-13-2024
{142}1	R-13-2038	INSULATOR	21793	R-13-2038
{147}1	R-18-1239	SCREEN	21793	R-18-1239
{243}2	R-23-9148	INSULATING BUSH, M3	K1935	J22-5006
{245}3	R-24-2801	WASHER, CRINKLE, M3	21793	R-24-2801
{247}8	R-24-3519	AV LUGS	19738	AVLUG1107/020B
{249}1	R-24-4146	STAND-OFF, M3X14	46384	KTF-M3-14-ET

REF DESIG	RACAL-DANA P/N	DESCRIPTION	FSC	MANUFACTURER'S P/N
C1-6	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C7	R-21-1781	CAP, CHIP, 3.3 PF	95275	VJ1206A3R3CF
C8-10	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C11	R-21-1781	CAP, CHIP, 3.3 PF	95275	VJ1206A3R3CF
C12-13	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C14	R-21-1781	CAP, CHIP, 3.3 PF	95275	VJ1206A3R3CF
C15	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C16	R-21-0795	CAP, ALUM. ELEC, 47 UF	28848	2222-036-36479
C17-18	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C19	R-21-1783	CAP, CHIP, 4.7 PF	95275	VJ1206N4R7CF
C21	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C22	R-21-1781	CAP, CHIP, 3.3 PF	95275	VJ1206A3R3CF
C23	R-21-1788	CAP, CHIP, 12 PF	95275	VJ1206A120JF
C24-25	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C26	R-21-1800	CAP, CHIP, 1 NF	95275	VJ1206Y102KF
C27	R-21-0795	CAP, ALUM. ELEC, 47 UF	28848	2222-036-36479
C28-32	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C33	R-21-1784	CAP, CHIP, 5.6 PF	95275	VJ1206A5R6CF
C34-36	R-21-1785	CAP, CHIP, 6.8 PF	95275	VJ1206A6R8CF
C37	R-21-1795	CAP, CHIP, 47 PG	95275	VJ1206A470JF
C38-39	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C40-41	R-21-1781	CAP, CHIP, 3.3 PF	95275	VJ1206A3R3CF
C42	R-21-1784	CAP, CHIP, 5.6 PF	95275	VJ1206A5R6CF
C43	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C44	R-21-0795	CAP, ALUM. ELEC, 47 UF	28848	2222-036-36479
C45	R-21-0704	CAP, ALUM. ELEC, 47 UF	28848	122-53479
C46	R-21-1782	CAP, CHIP, 3.9 PF	95275	VJ1206A3R9CF
C47-48	R-21-1801	CAP, CHIP, 10 NF	95275	VJ1206Y103MF
C49-50	R-21-1781	CAP, CHIP, 3.3 PF	95275	VJ1206A3R3CF
C51-52	R-21-1789	CAP, CHIP, 15 PF	95275	VJ1206A150JF
C53	100133	CAP, CERAM, .1 UF, LOW PROFILE, 20 PERCENT	32897	8131LP-100-25U-104M
D1	210089	DIODE, LOW OFFSET SCHOTTKY	50434	HP5082-2835
D2	R-22-1058	DIODE, SILICON	50434	5082-3379
D3	210089	DIODE, LOW OFFSET SCHOTTKY	50434	HP5082-2835
D5-6	210089	DIODE, LOW OFFSET SCHOTTKY	50434	HP5082-2835
D7	R-22-1058	DIODE, SILICON	50434	5082-3379
D8-9	210017	DIODE, MATCHED PAIR	21793	210017
D10-11	R-22-1814	DIODE, ZENER	25403	BZX79C9U1
D12	R-22-1029	DIODE, SILICON	14433	1N4149
IC1	230547	IC, QUAD COMPARATOR	27014	LM339N/A-1
IC2	230787	IC, DIGITAL TRIPLE LINE RECEIVER	04713	MC10116PDS
IC3	R-22-4694	IC, 1.3 GHZ PRESCALER	52648	SP4731
IC4	230193	IC, QUAD 2-INPUT NAND GATES	01295	SN74LS00N
L1	R-17-3240	COIL ASSY	21793	R-17-3240
Q1-3	R-22-6123	TRANSISTOR, NPN	82219	BFR90
Q4	R-22-6155	TRANSISTOR, RF	50434	HXTR-3101
R3-4	R-20-5768	RES, CHIP, 10K, 1/8W, 5 PCT	65940	MCR18-10K OHM-5 PCT
R5	R-20-5841	RES, CHIP, 150 OHM, 1W	56235	2021CPX151J
R6	R-20-5837	RES, CHIP, 39 OHM, 1W	56235	2021CPX390J
R7	R-20-5787	RES, CHIP, 330 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-330 OHM-5 PCT
R8	R-20-5783	RES, CHIP, 150 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-150 OHM-5 PCT
R9	R-20-5786	RES, CHIP, 270 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-270 OHM-5 PCT
R10	R-20-5764	RES, CHIP, 100 OHM, 1/8W, 5 PCT	65940	MCR18-100 OHM-5 PCT
R11	R-20-5786	RES, CHIP, 270 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-270 OHM-5 PCT
R12	R-20-5771	RES, CHIP, 10 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-10 OHM-5 PCT
R13	R-20-5776	RES, CHIP, 33 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-33 OHM-5 PCT
R14	R-20-5787	RES, CHIP, 330 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-330 OHM-5 PCT
R15	R-20-5786	RES, CHIP, 270 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-270 OHM-5 PCT

404626, PCB ASSY., CHANNEL C, REV. A continued

REF DESIG	RACAL-DANA P/N	DESCRIPTION	FSC	MANUFACTURER'S P/N
R16	R-20-5788	RES, CHIP, 390 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-390 OHM-5 PCT
R18	R-20-5771	RES, CHIP, 10 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-10 OHM-5 PCT
R19	R-20-5776	RES, CHIP, 33 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-33 OHM-5 PCT
R20	R-20-5787	RES, CHIP, 330 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-330 OHM-5 PCT
R21-22	R-20-5784	RES, CHIP, 180 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-180 OHM-5 PCT
R23	R-20-5788	RES, CHIP, 390 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-390 OHM-5 PCT
R24	R-20-5771	RES, CHIP, 10 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-10 OHM-5 PCT
R25	R-20-5776	RES, CHIP, 33 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-33 OHM-5 PCT
R26	R-20-5787	RES, CHIP, 330 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-330 OHM-5 PCT
R27	R-20-7049	POT, 20K PRE-SET	21793	R-20-7049
R28	R-20-5788	RES, CHIP, 390 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-390 OHM-5 PCT
R29	R-20-5813	RES, CHIP, 100K, 1/8W, 5 PCT, 200V	65940	MCR18-100K-5 PCT
R30	R-20-5771	RES, CHIP, 10 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-10 OHM-5 PCT
R31	R-20-5774	RES, CHIP, 22 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-22 OHM-5 PCT
R32	R-20-5785	RES, CHIP, 220 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-220 OHM-5 PCT
R33-34	R-20-5794	RES, CHIP, 1.5K, 1/8W, 5 PCT, 200V	65940	MCR18-1.5K-5 PCT
R35	R-20-5810	RES, CHIP, 56K, 1/8W, 5 PCT, 200V	65940	MCR18-56K OHM-5 PCT
R36	R-20-5771	RES, CHIP, 10 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-10 OHM-5 PCT
R37	R-20-5779	RES, CHIP, 56 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-56 OHM-5 PCT
R38	R-20-5810	RES, CHIP, 56K, 1/8W, 5 PCT, 200V	65940	MCR18-56K OHM-5 PCT
R39	R-20-5770	RES, CHIP, 1M, 1/8W, 5 PCT	65940	1M OHM-5 PCT
R41-42	R-20-5799	RES, CHIP, 4.7K, 1/8W, 5 PCT, 200V	65940	MCR18-4.7K-5 PCT
R44	R-20-5792	RES, CHIP, 1K, 1/8W, 5 PCT, 200V	65940	MCR18-1K-5 PCT
R45	R-20-5783	RES, CHIP, 150 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-150 OHM-5 PCT
R46-49	R-20-5775	RES, CHIP, 27 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-27 OHM-5 PCT
R50	R-20-5765	RES, CHIP, 470 OHM, 1/8W, 5 PCT	65940	MCR18-470 OHM-5 PCT
R52	R-20-5801	RES, CHIP, 6.8K, 1/8W, 5 PCT, 200V	65940	MCR18-6.8K-5 PCT
R53	R-20-5797	RES, CHIP, 3.3K, 1/8W, 5 PCT, 200V	65940	MCR18-3.3K-5 PCT
R54-55	R-20-5792	RES, CHIP, 1K, 1/8W, 5 PCT, 200V	65940	MCR18-1K-5 PCT
R56	R-20-5790	RES, CHIP, 680 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-680 OHM-5 PCT
R57	R-20-5766	RES, CHIP, 2.7K, 1/8W, 5 PCT	65940	MCR18-2.7K OHM-5 PCT
R58	R-20-5797	RES, CHIP, 3.3K, 1/8W, 5 PCT, 200V	65940	MCR18-3.3K-5 PCT
R59-62	R-20-5792	RES, CHIP, 1K, 1/8W, 5 PCT, 200V	65940	MCR18-1K-5 PCT
R66	R-20-5783	RES, CHIP, 150 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-150 OHM-5 PCT
R68-69	R-20-5770	RES, CHIP, 1M, 1/8W, 5 PCT	65940	1M OHM-5 PCT
R70-71	R-20-5771	RES, CHIP, 10 OHM, 1/8W, 5 PCT, 200V	65940	MCR18-10 OHM-5 PCT
SK7	R-23-5173	CONNECTOR, 30-WAY	K0536	M20-989-30-06
{4}1	601751	CABLE ASSY., COAX	21793	601751
{5}1	R-11-1737	COVER ASSY	21793	R-11-1737
{6}2	R-13-2103	SCREEN	21793	R-13-2103
{7}1	R-13-2104	COVER	21793	R-13-2104
{8}2	R-14-4000	SPACER	21793	R-14-4000
{10}1	R-18-1142	P.C. BOARD (UNLOADED)	21793	R-18-1142
{156}2	617042	NUT, HEX, M3	1CJ86	DIN934-M3
{158}2	R-24-2801	WASHER, CRINKLE, M3	21793	R-24-2801
{166}60MM	500022	WIRE, BARE COPPER/TIN, 22 GA	21793	500022

RACAL-DANA Instruments Inc.



SALES, APPLICATIONS AND SERVICE SUPPORT



RACAL-DANA INSTRUMENTS INC.

4 Goodyear Street

Irvine, California 92718

Telephone: 1-800 RAC-DANA

(714) 859-8999 (In CA)

Fax: (714) 859-2505

TRT: 188715

INTERNATIONAL SERVICE CENTERS

Racal-Dana Instruments Ltd., Hardley Industrial Estate, Hythe, Southampton, Hampshire SO4 6ZH, England, (0703) 843265, Telex: 47600

Racal-Dana Instruments S.A., 18 Avenue Dutartre, 78150 Le Chesnay, France (3) 955 88 88, Telex: 697215

Racal-Dana Instruments GmbH, Frankenforster Strasse 21, 5060 Bergisch Gladbach 1, Federal Republic of Germany, 2204 60081, Telex: 887 8428

Racal-Dana Instruments Italia srl, Via Mecenate 84/A, 20138 Milano, MI, Italy (02) 5062767/5052686/503444, Telex: 315697

REPAIR REQUEST FORM

To allow us to better understand your repair requests, we suggest you use the following outline and include a copy with your instrument to be sent to your local Racal-Dana repair facility.

Model Number _____ Options _____ Date _____

Serial Number _____ P. O.# _____

Company Name _____

Address _____

City _____ State _____ Zip Code _____

Contact _____ Phone Number _____

1. Describe, in detail, the problem and symptoms you are having.

2. If you are using your unit on the bus, please list the program strings used and the controller type, if possible.

3. List all input levels, and frequencies this failure occurs.

4. Indicate any repair work previously performed.

5. Please give any additional information you feel would be beneficial in facilitating a faster repair time. (I. E., modifications, etc.)

MP MASTER



MA31104